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RESPONDING TO THE PROBLEM OF GLOBAL WARMING

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENVIRONMENTAL PROTECTION

OF THE

COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS UNITED STATES SENATE

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

AUGUST 10, 1989—HARTFORD, CT

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METHODS OF RESPONDING TO THE PROBLEM OF GLOBAL WARMING

THURSDAY, AUGUST 10, 1989

U.S. SENATE,
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS,
SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION,
Hartford, CT.

The subcommittee met, pursuant to notice, at 9 a.m., at the Legislative Office Building, State Capitol, Hartford, CT, Hon. Joseph I. Lieberman (acting chairman of the subcommittee) presiding.

OPENING STATEMENT OF HON. JOSEPH I. LIEBERMAN, U.S. SENATOR FROM THE STATE OF CONNECTICUT

Senator LIEBERMAN. The subcommittee will come to order.

Let me ask the members of the State legislature who are here to join me at the table. I am delighted to welcome State Senator Doc Gunther, who has been a real fighter for a clean environment in Connecticut for as long as I can remember; in fact, he was probably doing it before I was born. I'm glad to welcome him; he's a good friend.

Representative Sid Holbrook is here. He too has been actively involved in environmental matters.

State Senator John Atkins and State Representative Pete Smith are here.

Is anybody else here?

Mr. CARUSO. Ken Caruso.

Senator LIEBERMAN. Ken Caruso. Sorry. Welcome.

Any other State legislators?

[No response.]

Senator LIEBERMAN. I will begin with an opening statement. It's a little informal, but I will be glad if the State legislators want to add anything to it. I brought the gavel from Washington, so that will officially begin the hearing.

This is a field hearing of the Subcommittee on Environmental Protection, which is being held at the request and with the support of Senator Quentin Burdick of North Dakota, who is the chairman of the full committee, and Senator Max Baucus of Montana, who is chairman of the Environmental Protection Subcommittee. The purpose of the hearing today is to gather testimony and information on the question of global warming, and particularly on some of the responses to global warming that are taking shape here in Connecticut and in a larger sense throughout the Northeast. Hopeful-

ly, the transcript of these proceedings will be of help to the United States Senate as it considers this important question.

Until recently, we responded to our environment as if we did not have the ability to affect it, and that is the truth. In a relatively recent period of time historically—only 10 generations ago, which is three lifetimes—the industrial revolution provided us with the technology to change the way we relate to the environment.

Unknown to us, we also have changed the environment itself. The fact is that in only a handful of generations we have unleashed a potentially lethal mix of pollutants into our atmosphere which threatens to affect us for generations to come. The speed with which we have altered our fragile atmosphere is alarming, and the consequences of what we have done continue to be the subject of much debate in the public and among policymakers.

I believe that to persist on our present course is to continue what is really a dangerous experiment, the results of which will be carried by succeeding generations of our children and their children. We may now have sown the seeds of an environmental nightmare, the harvest of which our children will be around to see. I hope that now is the time to set in motion some new policies which will move us toward a much more rational and positive relationship with our environment. It is with that in mind that we have called this hearing today.

There is a difference of opinion about our flexibility to depart from our present energy policies, which are really at the heart of the global warming problem. I think much of that debate focuses around the question of short-term costs and profits, which really ignores many of the societal costs that do not show up directly in our traditional balance sheets. But we all know that the cost of environmental and health damage associated with environmental problems and global warming are real and significant and that they are a direct result of the choices we have made about the kinds of energy and the types of energy we consume.

For instance, a recent study by the American Solar Energy Society estimated that the additional cost imposed on society by our continued use of fossil fuels—and I'm thinking here of health costs and environmental damage and governmental subsidies—actually exceeds $100 billion a year. Those are costs today and, of course, they don't reflect the threat of global warming tomorrow.

The United States, like the rest of the industrial world—the rest of the world, really—will eventually have to reduce our reliance on fossil fuels because by definition nonrenewable energy sources are going to be gone at some point. The only question is when, and how that transition to other sources of energy, hopefully renewable energy sources, will occur. Will it be a planned and smooth transition that takes place before we have done irreparable damage to our environment? Or will we make the change in desperation, after the error of our present course becomes clear?

I hope that this hearing will shed some light on those questions and will contribute to helping the public here in Connecticut to understand the choices that we have to make and appreciate some of the things that people here in Connecticut have done and are trying to do, and will help the United States Senate be an effective leader in this cause.

The format that we're going to follow today will address three interrelated issues. The first witness will discuss the dimensions of the global warming problem, some of the facts that we know about global warming.

The second panel of witnesses is going to examine the contribution that enhanced efficiency and conservation can make in reducing the demand for increased electric generating capacity and the mechanisms that we have to promote those savings.

The final group of witnesses will discuss the contributions that can be made by alternative means that are more environmentally attractive than the traditional ways we have had of generating electric power.

Because we have a number of witnesses and only a limited amount of time, I'm going to ask the witnesses to try to keep their statements brief. Don Rogich, my staff assistant, has brought his timer and when the bell goes off please try to wrap up your testimony. I look forward to hearing from all the witnesses.

Let me now ask the State legislators, whom I am delighted to have here today, if they would like to make any comments.

Doc.

Senator GUNTHER. Just a quick comment. I am a little disappointed that Sid and I have to leave for another very important meeting shortly. I would have liked to stay here because this is something I've been involved in for quite a long time now. We have begun to realize that CFCs need to be controlled. I see where General Motors said they are going to actually purge the refrigerants in automobile air conditioners.

In this past session of the legislature we had several bills addressing CFCs; we are deeply concerned.

Alternate fuels, ethanol and methanol, that subject really annoys me. For 15 years, back to the Carter Administration and Schlesinger and the Energy Department, there has been documentation that gasoline and petrochemical fuels are being distilled improperly. They are being distilled at too high a temperature. I'll oversimplify it. We have documentation that diesel fuels and gasolines cannot be completely burned. There is almost 20 percent contamination by middle distillates going into gasoline which can't be burned in the average combustion engine.

We can increase the mileage by 20 percent, increase the life of the engines by 100 percent. We have a whole cadre of things that can be done if they were properly refining fuels. Nobody would listen to us.

More recently, just this past year, we had a little exposé about putting home heating fuel in diesel fuel tanks in gas stations, and we can document it.

Senator LIEBERMAN. Right.

Senator GUNTHER. That's a double "no-no." That's worse than the fuel we're getting. So I don't know if this sort of thing gets attention.

Incidentally, the bottom line on ethanol and methanol, the State of Connecticut is replacing metal gasoline tanks with fiberglass tanks. I understand that the polymers or whatever they use in the fiberglass tanks do have a limit as to how much ethanol and methanol can be put in, and some of those can be dissolved; which

means that down the line if we get to the alternate fuels, and they are more than 10 percent, we can get into a position where we're going to be replacing the fiberglass tanks.

Perhaps somebody can tell me that isn't so, but the experts tell me that it is.

Senator LIEBERMAN. Come back to us. We're going to be here until noon; I would say that we probably won't get to the alternate energy part until around 11, so come back. We'll welcome you.

Mr. HOLBROOK. I would like to say one thing too, because I have to go with the Senator.

Senator LIEBERMAN. Sid.

Mr. HOLBROOK. I am very pleased that you are holding this hearing in the State of Connecticut. There were many legislative problems that faced our General Assembly this year because, in my opinion, I didn't believe they were problems that the State of Connecticut should be dealing with. I felt that it was something that the Federal Government should be dealing with, and that in order to take care of it there had to be national legislation.

I hope that this hearing bears fruit and I hope that the United States Senate, along with the members of the House, will take some action because it's our planet, the only place we have, and it has to be preserved.

One of the problems that I have with the system that exists now is that I think that—I don't know who, but I can probably figure why—there has been too much emphasis put on traditional fuels, such as fossil fuels. Even nuclear fuels, because it seems that those types of fuels can be controlled by a very few. I don't believe that there has been enough emphasis put on wind power, solar power, and even hydropower, because that is readily available to all the people at a very low cost. I wonder why the emphasis has been put primarily on fuels that are controlled by very few people in very few countries. I think that that's something that possibly should be looked into.

Senator LIEBERMAN. Thank you. I look forward to working with you.

Pete or John, did you want to say something?

Senator ATKINS. I just wanted to welcome you to the State Capitol, Joe, and I look forward to hearing this expert testimony.

As you know, Connecticut became one of the first States to pass its own global warming bill this past legislative session. As both Sid and Doc have said, we look forward to having the United States Congress involved in this.

Senator LIEBERMAN. Thank you.

Pete.

Mr. SMITH. Just to echo what John said, we had a public hearing on global warming and the environment in this last session. One of the frustrations definitely was the fact that much of the legislation we were looking at was more appropriately dealt with at the Federal level. I think we took some initiatives that show that the little State of Connecticut made its stand, but many of these issues are really of national consequence, and I do hope that the Federal Government does want to indeed take the lead on many of these issues as it has in the past.

Senator LIEBERMAN. Dan.

Mr. CARUSO. Thank you, Senator.

As you've heard before, the members of the Environment Committee and this General Assembly want to do our part so that Connecticut is contributing to solving the problem; but at the same time, we don't want to do it alone so that our efforts are dissipated, and particularly our financial constraints that we're going to be putting on our corporations and individuals. I think that's probably the major concern, because we want industry and business in Connecticut to prosper so that our whole State can prosper.

I think that the key is to do it so that we're not out of step with the rest of the Nation, but we do want to take a leadership role.

Senator LIEBERMAN. I appreciate what all of you have said. I'm really glad you're here. It just symbolizes to me that obviously this is a problem that we all share. It's a national problem and we all ought to work together on it. So I thank you.

It is unusual to introduce somebody from the press, but just to suggest that this is an international problem, I am pleased to have with us today Mr. Edgar Chiporov, who is from the Novosty Press Agency, and reports to several newspapers and journals in the Soviet Union. He is here today as part of a report he is doing on the life of a United States Senator. I don't know if I should let him talk to my wife or not.

In any case, I know from all that I've read that environmentalism today is a worldwide movement, certainly in the developed countries, and it is a very powerful force within the political life of the Soviet Union. So I am delighted to have him here, and particularly to hear of the concern that we have in Connecticut about global warming which clearly affects us all, wherever we live on the planet.

Now, Mary Mushinsky. Would you like to say anything? Nice to see you again. Congratulations.

Ms. MUSHINSKY. Thank you. I brought you a memo. We had a global warming bill this year in the State Senate. It was defeated, basically because the homebuilders got after it and took out a section about energy efficient homes; you weren't there to save it.

Senator LIEBERMAN. And Doc couldn't do it all alone.

Ms. MUSHINSKY. Doc couldn't fix it. Anyway, the Senate version was different from the House version, and the clock ran out on the bill on the last day. But the bill is mainly about energy efficiency in homes, in State buildings, State purchase of energy-efficient autos, and tree planting to offset CO_2 emissions.

At one time the committee had included mass transit also, but we ran into a problem with that from traditional highway interests. It looked like they were going to fight that, so we dropped it in the Environment Committee. So the bill is mainly about energy efficiency in buildings and autos. We will be running it again next year. It is probably something you should have, to see if we can work to dovetail with whatever the Federal versions are with this version.

Also, just a note that you should watch out for traditionalists in the homebuilding, highway construction, and automotive industries because you will hear from all three of them.

Senator LIEBERMAN. Okay. Thanks for the warning.

Let me say what the people here in Connecticut already know, which is that the Environment Committee of the State legislature is really on a bipartisan basis, and I'm glad that this group here is bipartisan. I think it has been a real national leader in dealing with environmental problems over the years. I'm proud of that and I look forward to going over the material that you've brought and I'm sure it will be of benefit to all of us.

Ms. MUSHINSKY. We're glad you're working on it too, because it's much easier to do this on a national level.

Senator LIEBERMAN. Sure. A while ago I went down to an energy-efficient home that UI opened up in Milford, and it was pretty impressive. It's worth seeing; it shows what can be done.

Okay, I thank all of you. Why don't we go to the first witness? This is a little bit unusual as a setup. We're going to go to Rafe, then the second panel, then the third panel, and I'll try to keep the discussion moving. We welcome the legislators to come back at any point they can; I know they have to go.

The first witness is Rafe Pomerance. Rafe is a native of Connecticut who is now working in Washington with one of the independent groups that has real credibility on this and other environmental issues, and that is the World Resources Institute. He is the Senior Associate there. We've asked him to come home today to talk a little bit about the state of scientific understanding of the global warming problem. My impression as a policymaker is that the evidence that the planet is warming is getting stronger and stronger, although there are still some skeptics.

But Rafe, we're glad to have you home and we look forward to your testimony now.

STATEMENT OF RAFE POMERANCE, SENIOR ASSOCIATE, WORLD RESOURCES INSTITUTE

Mr. POMERANCE. I thought I would just stand down here because my slides are down here and just take a few minutes to lay out the science, the state of what we know on the global warming problem.

First of all, let me say I am delighted to be here. Thank you for having the hearing. I'm glad to hear from so many State legislators about the activity going on in the State.

A word about the Environment Committee. In the Senate, the Environment Committee has been not only a national leader on this issue over the years, but really a global forum for bringing out the scientific evidence about global warming. It has had not only a national impact but a global impact through various hearings.

Let me begin with just a few words about the greenhouse effect itself. I'm sure that many of you know this in some detail, but it is always worth repeating, that the greenhouse effect is part of the life support system of our planet. Without the atmosphere that we have, the Earth would be about 63 degrees Fahrenheit colder.

We know that the greenhouse effect is important because scientists have compared our atmosphere to the atmosphere of Venus and Mars. Venus is terribly hot, mainly due not to its distance from the sun but because of its atmosphere, which has very concentrated amounts of carbon dioxide. Mars has a different atmosphere

and is very cold because it has a very thin atmosphere that doesn't attract solar energy.

If I might just draw a quick picture, the way I conceive of our atmosphere—what happens is that the solar energy comes in from the sun, is reradiated off the surface of the earth, and is then captured by the atmosphere. The radiation then runs into these molecules. That's the effect. That's the greenhouse effect, the trapping of infrared radiation coming off the earth.

The problem is that as you increase those concentrations you change the trapping capacity of the Earth's atmosphere.

So we know that the greenhouse effect is important by looking at other planets. We also know that it is important when we look back at historic climates of the Earth. Some very exciting scientific work has been done by Soviet and French scientists who looked in the Antarctic ice cores—they looked down, took out two kilometers of ice, a very deep drilling of ice, looked at it, 160,000 years old. What you can tell from this slide is that if you look back 160,000 years, the temperature of the earth was much colder. Also, the CO2 concentration was much lower than it is today. It rose from 200 to 280 parts per million. That's when the Earth came out of the glacial period and into an interglacial period like we have today. The CO_2 concentrations changed, and so the temperature rose. In the Antarctic, the temperature changed by about 25 degrees Fahrenheit, 12 degrees Centigrade, as the earth came out of the glacial period.

Again, about 20,000 or 18,000 years ago, the Earth—and Connecticut—came out of a glacial period and warmed up. You can see in this historic record the change in both global temperatures and the change in the composition of the atmosphere.

So that supports the hypothesis. A very important statement came out of a recent scientific workshop at Amherst when a group of scientists concluded that it is certain that increasing concentrations of carbon dioxide, methane, chlorofluorocarbons, and other trace gasses will enhance the greenhouse effect.

There have been a lot of arguments over how certain we are about this problem. This statement indicates that the scientific community is clear: raising the concentration of greenhouse gasses in the atmosphere will enhance the greenhouse effect.

Let me just turn briefly. There are five major greenhouse gasses: carbon dioxide, which comes from burning fossil fuels and deforestation; chlorofluorocarbons, which are now destroying the ozone layer, are also a greenhouse gas; methane, which comes from a number of sources; nitrous oxide from agricultural fertilizers; and ozone in the lower atmosphere is also a greenhouse gas.

I can go into more detail about sources, but perhaps it's useful to say that all the other gasses added up equal carbon dioxide in their contribution to the greenhouse effect.

Now, the question is, much of the science in this has been written like it is a future problem, something for the next generation to worry about. I wanted to address the question, is this a crisis today? It really is. It is a planetary crisis, and the reason for that is that due to the industrial revolution's past activities, the concentration of greenhouse gasses in the atmosphere has already gone up an enormous amount.

I'll just put this slide on. This is CO_2 measured in ice cores from 1740 to the current period. You can see that CO_2 has gone from about 280 parts per million to 350. That's a rise of 25 percent. Now, when we went from glacial—ice covering much of North America—to the current interglacial, the CO_2 concentrations went up 40 percent. They are on the same order of magnitude. We have already altered the atmosphere as much as occurred during in climate years from the glacial to the interglacial period. It's a big change that has already occurred.

Now, there is a delay between the time we put all that CO_2 in the atmosphere and when the earth warms up because the oceans absorb the heat first and it doesn't show up on the surface. Scientists have now concluded that past emissions of carbon dioxide have already committed the Earth to as much as a 2-degree to 4-degree Fahrenheit warming. Cut out all CO_2, all greenhouse gasses today, and the Earth will still warm significantly. In fact, the Earth hasn't been more than 2 degrees Centigrade or 4 degrees Fahrenheit warmer for 2 million years, since the start of the interglacial period.

Future emissions will carry us far beyond this, into regimes that probably haven't been unearthed for tens of millions of years. We will make those decisions today. Those are being made now with current energy problems, as to whether we're going to run this sort of risk. In fact, we're returning as far as the Cretaceous period when dinosaurs roamed the Earth. We're talking about warming the earth to very, very extreme temperatures.

So in a way, the issue has arrived for policymakers because of past emissions and the rising rate of current emissions. We already have a problem, no matter what we do.

Now, what about the effects of climate change? I actually have here a slide that indicates the last point. It's a nice slide. This is the temperature over the past 160,000 years, again, from the ice core. You can see how they sit between this 5 degree Centigrade range. There you see the year 2000. That's what happens to global temperatures. They just shoot up, in basically a zero time frame, way out of the range over the past 160,000 years. This is something that might be called a "superinterglacial period," very warm indeed.

So what will happen if the Earth warms? Well, as much as we can predict, there will be an equal amount of surprises. Our ability to predict the future is limited. In fact, one of the most serious observers of the global climate system, Wally Broker from LaMont Labs, has said that we should really expect very large surprises in that the Earth's system might operate in a nonlinear way; that is, it won't be a gradual change, but the Earth may switch in and out of completely different climate systems, crossing thresholds.

Broker recently remarked that the past records of climate screamed to us, that the Earth's climate is highly sensitive to nudges. The issue is that by adding infrared absorbent gasses to the atmosphere, we are effectively playing Russian Roulette with our climate.

What are some of the conventional views of what might happen? Well, the Earth warms; the oceans warm; the sea level rises because they expand. Rainfall patterns will shift. Agricultural zones

will shift. As you know, global grain production is very sensitive to drought. We don't have very many double drought years; if we do, consumption will exceed production and you will get rising food prices around the world, which can become politically destabilizing.

Natural ecosystems survive. Connecticut's forests survive in a certain temperature range, certain precipitation patterns. Change those, and the forests in the temperate zone may not survive. They may die off, unable to migrate at rates at which the climate changes. A number of colleges believe that the natural systems of the Earth simply cannot accommodate themselves to a rapid rate of climate change.

Finally, about the Clean Air Act, there are some indirect greenhouse gasses that are regulated by the Clean Air Act. The Clean Air Act does not basically regulate CO_2 or methane. It controls chlorofluorocarbons through the stratospheric ozone divisions, but nitrogen oxides and carbon monoxide are indirect greenhouse gasses through atmosphere chemistry, contributing to the increasing concentration of ozone and methane. So the Clean Air Act does have an important role. One might suggest looking at the whole question of national emissions rather than regulating many of the emissions on a regional basis, because this is a national problem in the greenhouse context.

What about the United States? The United States for four decades has been the world's largest emitter of greenhouse gasses. Today our share has declined, but we are still the biggest emitter; and with the Soviet Union, together our emissions make up almost 50 percent of the global CO_2 problem.

You can see from this slide—this is emissions from U.S. electric utilities. In the United States, our emissions exceed the total CO_2 emissions for all these regions or countries—all of Latin America—just from our utilities alone, all of Japan, cars, homes, utilities. Our emissions just from our electricity sector are larger. The same is true of the transportation sector: West Germany, Southeast Asia, Great Britain, all of Africa, and France. So you can see that we're the big player. If we don't move, the world doesn't move.

In 1987, however, our share stopped declining and started rising. We started to become a bigger part of the global share. This is a very dangerous trend because it will isolate the United States internationally. We will become the target, globally, for people to say, "Well, if the United States isn't willing to do anything about its energy policies, why should we?" Why the Chinese, why the Indians, why the Russians?

Our per capita use is second in the world, the second most amount of CO_2 per capita of any country in the world. So in some ways we have the farthest to go.

Now, Secretary Watkins of the Department of Energy has announced plans to develop a national energy strategy. At this point they haven't committed themselves to any CO_2 reductions in that strategy.

Two final points. The G–7 Summit was a remarkable document. Many commitments were made by President Bush and the other leaders. There are rhetorical commitments in that statement. The question is whether heads of state will live up to that. We're in a great position to judge whether that happens, because the next eco-

nomic summit is in the United States, and the President committed himself to concluding a global treaty on climate change and controlling CO_2 and other greenhouse gasses. But that is rhetoric at this point. There are no concrete plans, no dates, no numbers for achieving those goals.

Finally, there was an interesting discussion about the role of States here before I began my testimony. I made a few suggestions about the State role. Let me just say that I think the leadership on this issue may indeed come from the States. When the States move, it forces the Congress sometimes to move because industry does not like to be regulated on a State-by-State basis. But more importantly, there are examples in the States that the Federal Government may learn from.

I suggest three things that States need to look at. One is how to control greenhouse gasses in the State. New York State is considering setting a 20-percent reduction target on its own CO_2 emissions right now.

Second, looking at the impacts—what will sea level rise do to the Connecticut coast? What will happen as far as agriculture is concerned?

And finally, what are the business opportunities for the States? We're going to need—we may need—a whole new energy system in this country and in the world. Well, who is going to make those products? Who is going to sell them? There are major opportunities in this issue for new technologies and new industries.

Thank you.

Senator LIEBERMAN. Thank you, Rafe. Let me just say to you and to all the other witnesses that your prepared testimony will be included as part of the record.

Rafe, let me just ask you a few questions before we move on.

Is it fair to conclude that the prevailing opinion in scientific circles is consistent with the fairly dire projections that you gave us? Or is there still substantial controversy about that?

Mr. POMERANCE. The agreement is that greenhouse gasses will warm the Earth. The exact rate and magnitude are less certain, but there is a range about how big the warming will be. The regional impacts are less certain than are the overall global impacts.

There is a significant body of opinion that thinks the risks are very high. There is a body of opinion that thinks we can't predict it very well. When you get down to a regional basis, what will happen in New England, it is very difficult to predict what future rainfall will be. We don't know quite how high the seas will rise. We don't know how strong hurricanes will become. But there is agreement that rainfall patterns will change; deserts may move.

The large scale changes are agreed to, but regional prediction is very difficult.

Senator LIEBERMAN. That was actually my next question, which is whether it is possible, if policy and behavior do not change, to project in a microcosmic way what life will be like in Connecticut at the end of the next century.

Mr. POMERANCE. Well, the EPA did a report on the potential effects of climate change. They broke it down by region. Essentially, they gave a range of potential outcomes. With some issues it is easier to narrow the range than with others. The sea level issue is

pretty clear. You can take a rate of sea level increase and a range of heights and figure out where the shoreline would be in a hundred years, how much real estate will be lost, how much wetlands will be lost as the shore moves inland. You can do that sort of thing. You can look at what kinds of trees ought to grow here in a hundred years, if they can migrate this far north, and why oaks, maples, beeches may not. You can look at what happens to highways if the weather is going to be an average of 10-degrees warmer in the summer.

Senator LIEBERMAN. Is that what we're talking about, the possibility of an average 10 degree increase?

Mr. POMERANCE. Yes. The reason is that by 2030, in 40 years, we can be committed to a warming of—let's take the global average, the middle of the spectrum. Six degrees Fahrenheit global average warming by 2030. That is committed to. It won't have all shown up by then.

Now, at high latitudes, particularly in the northern hemisphere, it's supposed to be much higher than that. It might go to as much as 18 degrees Fahrenheit at the pole, and between that 6 and 18 degrees in the midlatitudes. So it might be 8 or 10 degrees Fahrenheit here. The reason is that you melt all the sea ice in the polar latitudes; that changes the reflectivity of the planet, the poles warm up a good deal.

Senator LIEBERMAN. So I assume, just to bring it close to home, that there is little doubt in your mind, based on what you know, that if the trends continue the waters of Long Island Sound, for instance, will rise and we will lose some existing coastland beaches?

Mr. POMERANCE. Yes, that's right. There are various groups in the State and in EPA making estimates of how large that might be and what the impacts might be.

Senator LIEBERMAN. Do you have any idea what the range of estimates could be?

Mr. POMERANCE. Oh, it could be as much as 3 feet in the next century. But the ranges—there are more catastrophic estimates. It would take a lot longer. The West Antarctic ice sheet, which could raise sea levels several meters worldwide, rests very gingerly in the Antarctic, and warming of the oceans could allow it to slip into the ocean. So over a longer time we could have a more catastrophic rise.

Senator LIEBERMAN. You mentioned the possibility of food prices rising as the result of drought. Can you portray for us any other changes in lifestyle?

Mr. POMERANCE. Well, one has to think of this on a global basis. For example, the whole Indian subcontinent, with over 1 billion people now—certainly, India itself will exceed 1 billion people—is dependent on the monsoons. They are a reasonably regular event, triggered by temperature differentials between land and sea. If you change the time and magnitude of the monsoon you can create tremendous political difficulties in the Indian subcontinent—migrations, food shortages. The developing world is highly sensitive to climate changes, as we've witnessed in Africa with the famines.

So you can trigger political difficulties. In other regions—the possibility exists of migrations——

Senator LIEBERMAN. Human migrations?

Mr. POMERANCE [continuing] Human migrations, because climates no longer become tolerable. For instance, Bangladesh is very low-lying; millions of people live in the flood plain which will no longer exist. The sea level will just move too far inland; people will have to move. Those countries are overpopulated now, so it will simply stress things a little more.

Senator LIEBERMAN. Can you foresee any human migrations here in the United States as a result of global warming?

Mr. POMERANCE. Well, we would probably have to abandon some shorelines in the United States, and over time the coastline which is very densely populated might lose some of its land mass.

I don't know if southern climates—if Phoenix-like temperatures, which are 110 in the summer, move to wider ranges in the southern tiers of the United States, whether everybody who lives there now would be willing to deal with those kinds of temperatures. Let's say you have an area that is wet now, becomes a desert. Will people be willing to stay?

The agricultural zones of the midwest will become a more arid, steppe-like environment. The grain belts, for example, could turn into much less productive areas, as we had in the 1930s. During the dust bowl there was substantial migration, and that sort of thing could occur again.

Senator LIEBERMAN. Let me ask you now about some of your worldwide experiences, and in particular if you would talk a little bit more—because I know you were in Paris for the Group of Seven meeting—about what your sense is about awareness of the problem internationally, and about the willingness internationally to do something.

Mr. POMERANCE. Well, the awareness has grown enormously in the past few years. It is amazing in some ways that the seven heads of state said what they did about the environment. One-third of the declaration was the environment and the substantial concerns; in fact, the leading statement said that we must take decisive action to save the Earth. That's a slight paraphrase, but it says we must take decisive action. It didn't define all those decisive actions; but there, the heads of state representing about 60 percent of the world's GNP, 12 percent of its population, 40 percent of its CO_2 emissions, said that we have to take decisive action.

So when you get heads of state speaking that way, things are moving. We have never confronted a problem like this where you have to transform a global energy system, potentially, and in a relatively short period of time. The market won't take us there. With current prices and current directions, you can't do it; governments have to intervene. You're dealing with the entire globe. The awareness is up and the commitment is growing. Whether we're in time is an open question; that depends on how fast we move and how extreme these things turn out to be.

Senator LIEBERMAN. It strikes me that there's a potential here, without seeming too Utopian about it, that because of the extent to which this is really a problem that affects everybody on the globe, that it may also—at least in this area of our relationships—create more coherent working together in the international community than we've had on anything else because we do have a common enemy here, all of us. Do you sense that? Do you see the interna-

tional institutions existing? Or are there sufficient institutions to meld that movement?

Mr. POMERANCE. The question of institutions—in the Group of Seven they called for strengthening the U.N. on this issue, and it has to be done.

In some sense, the question of whether we can cooperate on this is dependent on leadership of the industrialized world, particularly the G–7 countries, because that's where the financial capability to deal with this exists. There's going to have to be some kind of north-south bargain where we assist developing countries to stop the deforestation of the tropics, while we make our automobiles more energy-efficient, far more efficient.

The East Bloc is a totally different problem. Their economies are in disarray. How they come out of this is another question. They are big carbon dioxide producers.

It has the potential to unify, particularly if we see a clear-cut signal of global warming. Then I think you could see a very big change in global politics. It has that potential.

Senator LIEBERMAN. You mean, if there was an actual event?

Mr. POMERANCE. If the scientists agreed that we have actually confirmed that the Earth is warming. Some people believe it is. There is no unanimity now. The 6 warmest years in the entire last century have been in the 1980s; 1988 was the warmest year, but that's still not proof for many. Another event like last summer that is clearly a greenhouse event might do it.

But I've been amazed that people are really taking the issue very seriously. At a rhetorical level they're learning about it, and the question is whether we can move quickly enough.

Now, with CFCs, that happened. Within 3 years, with DuPont—well, it's a little more complicated, but it's really been less than 3 years since we got a U.S. proposal on the table to reduce CFCs. The world now has agreed to control them, and everybody has basically agreed to a phase-out by the end of the century. That's within 3 years.

Part of the key to that was the commitment by major multinational corporations to do the phase-out. You can't make this work unless the private sector begins to believe it as well and takes an active role. That is critical.

Senator LIEBERMAN. Okay. That's a magnificent transitional sentence.

Thank you for taking the time to come back home. It's a pleasure to have you here, and thank you for all you do in Washington as well.

Now we want to focus on the potential contribution of efficiency and conservation, to take a look at some of the things that have happened here in Connecticut that I'm proud of, because I think they may suggest a leadership role for our State and something that others around the country can follow.

This panel consists of Dr. John Cagnetta, Senior Vice-President for Corporate Planning and Regulatory Relations at Northeast Utilities; Mr. Armand Cohen, who is a senior attorney at the Conservation Law Foundation of New England; and Jim Meehan, who is the Consumer Counsel here in Connecticut; and Peter Boucher, who is Chairman of the Public Utilities Commission.

Dr. Cagnetta, we will start with you.

STATEMENT OF JOHN CAGNETTA, SENIOR VICE-PRESIDENT FOR CORPORATE PLANNING AND REGULATORY RELATIONS, NORTHEAST UTILITIES

Mr. CAGNETTA. Thank you, Senator Lieberman. I appreciate the opportunity to provide a utilities perspective on the programs that are in place or could be deployed to address the global warming crisis.

In my written testimony I have summarized two decades of Northeast Utilities' resource planning which has contributed to reducing dependence on fossil fuels. In my written testimony I also address some legislative actions that could assist utilities in implementing programs that mitigate global warming.

Clearly, more efficient use of fossil fuel resources is first priority, whether it be for direct process heat applications or for the generation of electricity. Efficient use of electricity goes hand-in-hand with efficient use of the primary fuels.

Northeast Utilities has expanded its customer conservation and management programs. I have provided a summary of these programs in my written testimony. The new Northeast Utilities programs have been a result of a pioneering collaborative design process that is being emulated now by many other utilities. Regulators are excited about it, and interested parties elsewhere are talking about it.

Our collaborative process involves all the advocates of conservation, including the State of Connecticut Office of Consumer Counsel; they have been very active on it. This effort has been encouraged by the Connecticut DPUC, which recently approved the programs for implementation that are ongoing today. A similar effort was accomplished in Massachusetts, where NU coordinated a similar collaborative effort which included five of the utilities in Massachusetts, the Massachusetts Energy Office, the Attorney General's Office, and the Massachusetts Public Interest Group. The Conservation Law Foundation was active in this collaborative process, too.

The Northeast Utilities programs to date have reduced our peak load by 220 megawatts, and we expect the expanded programs to achieve some 600 megawatts in peak power reduction, which represents about a 10-percent reduction to our load. The magnitude of that conservation achievement is about equal to the output of one of our smaller nuclear plants.

We look to you for some support in institutionalizing the gains in these conservation programs by way of legislative action on upgrading compliance and building standards. Connecticut has taken action with regard to building standards for residential homes, and is moving forward, hopefully, on commercial building standards.

But even with aggressive conservation programs we expect our electric load to increase in the future. Hence, it is important to fully utilize those supply options that we have today; that is, those that do not contribute to global warming. For NU, the appropriate supply options have been nuclear and hydro. I have in the written testimony some impressive numbers of the amount of carbon dioxide that would be produced annually, as well as nitrous oxide, if

our commitment for the last 20 years had been with coal rather than nuclear or hydro.

We look for your support in maintaining nuclear power as a viable resource, which today is essential for meeting not only our existing load in Connecticut, but in meeting New England's capacity needs.

In addition, there may be future opportunities to expand our hydro capability. Here again we look for your support, especially in reaching out for hydro capability beyond our service area.

Future options that could make significant contributions to mitigating global warming are solar technologies and new nuclear technologies, such as fusion or advanced fusion plants. We should give these undeveloped supply options priority in R&D funding to bring them to early commercialization. That would also apply to demand options, because clearly there are further opportunities for research and development on some of the conservation technologies and the energy-efficient technologies.

In the interim, what we see here in New England is a continued dependence on natural gas to satisfy our demand, which appears to be a better option than additional dependence on oil and coal. In this regard, we look for your support in expanding the New England Natural Gas Pipeline capability.

With respect to continued use of fossil fuels, it is important that utilities continue to play a role in the development of cogeneration potential, for this supply option can achieve greater overall efficiencies with fossil fuel use than a power plant that uses fossil fuels alone. Here again, we look for your support in amending the Public Utility Holding Company Act so that companies like Northeast Utilities could develop cogeneration—and for that matter, renewable resources—with constraints which are not greater than those faced by exempted utilities or independent third parties.

In summary, there are demand and supply options that can provide the electric service without adversely contributing to global warming, and we are prepared to assist your committee in the development of these options.

Senator LIEBERMAN. Thank you.

I would like to go on to the other two members of this panel, and then come back and have some discussion.

Mr. Armand Cohen from the Conservation Law Foundation of New England.

STATEMENT OF ARMAND COHEN, SENIOR ATTORNEY, CONSERVATION LAW FOUNDATION OF NEW ENGLAND

Mr. COHEN. Thank you, Mr. Chairman.

As Dr. Cagnetta suggested, CLF has been involved in working on some positive solutions in this area. Right now we are involved in negotiating with 11 separate electric companies throughout the region to try to put aggressive efficiency programs in place.

If I want to leave you with one single message this morning, it is this. Despite the debate and some dispute about whether global warming is happening or how much, I would like to leave you with this thought: that if global warming is a reality, then energy efficiency is an extremely important solution. If global warming is not

happening, energy efficiency is still an imperative public policy because it is a lot cheaper than generating electricity through other means.

With some slides, I just want to walk very quickly through some of the concepts that are being explored right now in New England and their significance for this problem.

It is obvious that we have to concentrate on electric utility production and electric demand as a major part of the CO_2 equation because—I think Rafe mentioned this in his testimony—electric utilities alone account for about a third of the man-made CO_2 emissions.

As a way of addressing this efficiency problem, I thought I would bring it down to earth by looking at one specific end use of electricity, lighting, which—as you can see from this chart—consumes about one quarter of the electricity produced in New England, by walking through how a specific technology, high-efficiency light bulbs, to illustrate how this very practical, commercially available technology could play a role in mitigating global warming. There are a couple versions of this technology; they come in many shapes and sizes and fit all kinds of home and commercial uses.

As you can see, this technology is nothing more complex than a fluorescent tube wrapped inside a bulb with high efficiency ballast, and it consumes approximately a quarter of the electricity of conventional incandescent bulbs but puts out the same level and quality of light.

Installing just one of these high efficiency bulbs in a residential home in New England can have some spectacular impacts on global warming and on other forms of pollution from electric generation. The electricity avoided by this bulb reduces the need to burn about 524 pounds of coal, about 40 gallons of oil—that's enough oil to get you to Chicago and back in your car—and, depending on whether you are looking at oil or coal, will avoid somewhere between 220 and 400 pounds of CO_2 emissions into the atmosphere. It's a very powerful technology with a lot of "bang for the buck" from an environmental standpoint.

If we really step up energy efficiency and manage to get these kinds of bulbs installed, and other kinds of energy-efficient technology—I refer in my testimony to high-frequency magnetic ballasts which fit into a conventional office building, for lamp fixtures—just installing one of those will avoid about half a ton of coal throughout its lifetime. So we are talking about very big numbers.

Obviously, the benefits of energy efficiency aren't just in the CO_2 direction. Power plants in the U.S. account for about two-thirds of the sulfur dioxide problem, and about a third of the nitrous oxide problem, which is a very important contributor to the ozone problem and urban smog.

I guess what I'd like to do here is talk about some of the total potential that we see for these kinds of technologies in New England and nationally.

About 2 years ago we released a study which just looked at New England and looked at the potential for installing high-efficiency lighting, high-efficiency motors, and high-efficiency ventilation and cooling equipment in buildings. This chart represents the kinds of savings that we've seen from readily available commercial technol-

ogy. The red lines represent what is in place, on average, today. The blue lines, which are much smaller—showing that they consume much less electricity—show what can be done by putting those bulbs in place, and other high-efficiency equipment.

When you add it all up you do get a range of possibilities. This chart represents projections of electric demand in New England. The red line represents what New England's electric utilities project to be the electric demand in the year 2005, with only the level of energy efficiency that was in place in 1985. The yellow line is what CLF has projected could be the case, essentially the level of electric demand growth, even with very high underlying demographic and economic growth in New England, with high-efficiency technology. The blue line, which shows an absolute decrease in electric consumption despite projected high growth rates in New England in the manufacturing sector and in population, represents what we could do, assuming that these light bulbs get better and cheaper. The trend in the last 10 years has been that this stuff is getting a lot cheaper and is getting a lot more sophisticated. It is because of mass production that costs are coming down.

Senator LIEBERMAN. How much does it cost now?

Mr. COHEN. Well, part of the problem is—and I will quickly summarize it—it costs a lot for the consumer to go out and buy these on his own, which is why they're not being purchased. On a wholesale basis, that will run anywhere from $5 to $12. However, it produces electricity for about $0.02 per kilowatt hour. Any of our conventional generating technologies—and here, the blue line represents what has been proposed in New England—indicate a much higher response.

Senator LIEBERMAN. Are these available today in hardware stores?

Mr. COHEN. They are not, by and large.

Just to really skip to the punch line of my presentation, the programs that CLF has developed with Northeast Utilities and with the Office of Consumer Counsel under the DPUC's direction, really are focused on getting them widely saturated in retail stores, as well as directly installed in homes. The concept behind these programs is that the utility really has to go out and make that investment, because I as a homeowner am sure not inclined to go lay out $5 or $10 for a single bulb. It's that difference in the payback horizon of homeowners, business people, and utilities that has a much longer planning horizon, that means that utility capital, energy, and expertise is going to have to go into getting these kinds of improvements in place.

With that I will stop. In my written testimony I have gone a lot further, and you can pursue any details you wish.

Senator LIEBERMAN. I appreciate it, Armand. Thank you.

Since we last looked around the table, some more legislators have arrived. Let me just go around and ask them to introduce themselves.

[Legislators introduced.]

Senator LIEBERMAN. I appreciate all of you coming. It shows that it is a problem that obviously concerns all of us. Again, as we said at the beginning, it is something that we want to work together on at all levels of government.

Now we have Peter Boucher, Chairman of the State PUC, and Jim Meehan, the Connecticut Consumer Counsel, to share some of their experiences in this area with us. I thank you for coming. You were among the favorite ways I spent my time in my earlier incarnation as Attorney General. It's nice to see you again.

Mr. MEEHAN. Peter or me?

Senator LIEBERMAN. Well, you were my partner, and he was the judge.

STATEMENT OF PETER BOUCHER, CHAIRMAN, PUBLIC UTILITIES COMMISSION, STATE OF CONNECTICUT

Mr. BOUCHER. The tables are somewhat reversed, but I would certainly like to welcome Senator Lieberman.

I have a brief prepared statement and I will be happy to respond to questions after getting it into the record.

The balancing of interests in utility regulatory proceedings has grown more complex as we have begun to identify and consider new factors, including the pressing environmental concerns associated with energy production and use. Resolution of many matters must move beyond the traditional regulatory framework to new techniques of consensus building and policy development while retaining the ultimate tool of regulatory authority. The problems being addressed here today are national in scope, but State and regional actions are crucial components of any strategy to resolve them.

I would like to describe briefly the innovations undertaken in Connecticut through our regulatory proceedings and our participation in regional efforts. I believe these steps are appropriate components of an effective regulatory response to the urgency of energy-related environmental degradation.

Let me indicate at the outset that a significant amount, almost one quarter, of New England's power is generated by nuclear technology. Although I do not recall that global warming was among the original justifications for the nuclear option, it is today a fact.

It is, of course, the case today that conservation and energy efficiency can promote social objectives, not the least of which is a reduction in the burning of fossil fuels. Economic growth, assistance for low-income customers, load management to minimize capital investment, and regional electric efficiency are other essential goals that regulators recognize in designing and implementing conservation programs.

As I mentioned, the successful attainment of these goals requires innovative and creative regulation. In Connecticut, we initiated a process in 1987 designed to ensure that conservation activities moved beyond the study and analysis stages in which many utilities were mired. Our decision in a major rate case involving CNP directed that the utility enter into a collaborative conservation program design effort with the concerned parties and experts. These included DPUC staff, the Office of Consumer Counsel, the Office of Policy and Management-Energy Division, and the Conservation Law Foundation, from whom you have just heard.

Our decision provided a policy framework, focusing on low-income customers, targeted industries, and lost opportunities, to

guide the collaborative work group in the design of programs. I should note that this decision was the latest step in a multiyear process that had included development of an integrated demand/supply plan. That plan provided all of the necessary economic analyses that formed the basis of the collaborative design effort. The effort has proven successful to date in that programs have been implemented, and we will soon have empirical evaluations on which to base future expenditure authorizations.

Although not necessarily a measure of effectiveness, the DPUC has authorized expenditures in the case of CNP totalling $24 million, an amount well beyond that which was originally proposed by those activities. It takes regulatory commitment and confidence to authorize increased utility expenditures. It is our belief that the long-term benefits of reduced generating capacity need and the concomitant reduction in fuel burning, along with the reduction in individual customer consumption which can result in lower monthly bills, warrant this level of expense.

The Department also has been in the forefront of the movement for alternative methods of meeting electricity supply requirements. We have implemented regulations for private power producers to bid to fulfill utility capacity needs and have made special provisions to encourage the use of renewable resources. In addition, we currently have regulations undergoing legislative review which would allow for electric capacity needs to be met through conservation and demand management measures from private power providers. Private power producers and private power providers would compete on an equal basis in the bidding process. Among the criteria for judging competing proposals are fuel use and environmental impacts. The Department has adopted these regulations and we anticipate approval in early fall.

On another front, Connecticut has been working aggressively with the regulators and energy policy officials of the region to improve the regional power pooling arrangements. Many of the areas under study or change relate directly to the objective of conservation and efficiency to reduce the need to burn fossil fuels. As with the collaborative conservation program design effort in Connecticut, this regional effort is outside of traditional regulatory practices. The New England Governors' Conference created a Power Planning Committee to develop and implement a plan to assure adequate electricity supplies in New England. Conservation and load management are significant components of that plan. Independently, the Connecticut DPUC, at Governor O'Neill's request, commissioned an audit of NEPOOL which identified potential improvements that would encourage and enhance the contribution of conservation to the region. One of the key components of this strategy as it pertains to conservation is assuring that the charges applied by the pool for power provided to capacity-short utilities are high enough to successfully promote the necessary investment in conservation.

Connecticut has argued this point at FERC and the matter is under debate at the regional Power Planning Committee even as we speak, but as always, there are many different factors that influence such decisions. I discussed this matter in some detail in the

July issue of Electric Potential, and I have brought sufficient copies for members of the subcommittee to read.

To conclude, my advice is that regulators must look beyond their hearing room walls for opportunities to enhance the development and implementation of conservation. I believe Connecticut's collaborative conservation design program, our encouragement of private power providers, and the regional electricity planning process of the New England Governors' Conference are appropriate and effective responses to the ever-increasing need to institute policies and actions to assure the implementation of conservation and energy efficiency improvements.

If I could depart for a brief moment to highlight another issue that is somewhat unique, at least in my suspicion, to Connecticut in terms of its relationship to the regional power pool.

Connecticut's electricity needs are being met through a six-State regional power pool. Connecticut, at the present time at least, is home to utilities which more than currently meet the needs of their electricity requirements, which is not the case elsewhere within the power pool. So an issue with which we are grappling right now is how to ensure that excess or surplus capacity that materializes as the result of successful conservation and demand management programs in Connecticut—we need to assure ourselves that that surplus capacity is going to have a fair market within which to be made available to other regions within those six States. That's not a resolved issue, but it is something that needs to be resolved and resolved successfully in order for Connecticut, from the standpoint of equity, to be fairly compensated for being successful. I submit that it is being successful in promoting energy conservation and demand side management questions.

With that, I conclude my comments and I will be happy to answer any questions.

Senator LIEBERMAN. Thank you.

Jim Meehan, welcome. It's good to see you again.

STATEMENT OF JAMES F. MEEHAN, CONSUMER COUNSEL, CONNECTICUT OFFICE OF CONSUMER COUNSEL

Mr. MEEHAN. Thank you, Senator. It's a pleasure to be here; and members of the General Assembly, it's a pleasure to see you.

I would like to start by indicating how appropriate it is to hold the hearings here in Connecticut because most of the work in global warming and energy efficiency is taking place outside of Washington's Beltway. In fact, that's a direct result of the real abandonment of the national energy policy beginning in 1980 by our national Government.

Today's expenditures for research and development on energy conservation, as you know, Senator, are 25 to 35 percent of the levels of the pre-Reagan Administration period. The greenhouse effect was created in part by the "White House effect" which led our Nation to abandonment of principles of active Federal involvement in planning a national energy policy.

We do commend the Congress' recent action of resisting the Bush Administration's efforts to cut the research and development budget by 50 percent. The Congress did provide for an inflationary

increase of the DOE budget that was appropriate; but again, more needs to be done than just a mere inflationary increase in an already-reduced program effort.

We in Connecticut do have some successes to look to. The Connecticut model has been where the parties have at first been involved in very contentious and difficult litigation; the kind of good will that you've seen today did not come without periods of heat and thunder. We probably contributed a bit to the greenhouse effect ourselves during that litigation.

But the result of it has been very good. I think the Connecticut Light and Power Company deserves to be congratulated in this area. They have operated well with our office, with Armand Cohen, and with the DPUC to design a program and a process which has been exported to other States in New England and now across the country. It has provided the model upon which advocates and consumers as well as utilities can solve a very difficult problem.

We are using the conservation program in Connecticut not just to take care of energy problems but to take care of other problems, and on that I would just pick up on Rafe Pomerance's comments. There are great economic opportunities for Connecticut and New England in the energy efficiency area. We have been involved with Pratt & Whitney, trying to improve their energy position by making major investments by Connecticut Light and Power Company on the shop floor. This is seen as a way of retaining jobs here in Connecticut in spite of the fact that our electric rates are perhaps two times the amount that they are with some competitors throughout the United States.

We also have used the energy efficiency program to try to save the family farm in Connecticut, which is facing great difficulties with the farm economy. It has been used to tackle very stubborn problems with low-income households and their inability to pay energy bills in light of cutbacks in Federal aid to energy services, which I know you, Senator, have attempted to fight.

But more can be done here in Connecticut. We currently spend approximately $27 million a year through Connecticut Light and Power Company on energy efficiency investments, which is much more significant than most utilities in the country. We are going to be calling for an increase to over $40 million a year beginning in the next program year, which we think will begin to address the problem seriously.

Natural gas utilities and oil dealers also have to be brought into the fold here. It's not just up to the electric utilities to be concerned about it. Natural gas utilities and oil dealers must begin in a meaningful fashion to enter into the conservation area. That's something that we will be hearing more about in the coming months. I would add the oil dealers to the group of institutions that you have to wrestle with on these very difficult issues.

We do have some specific recommendations in trying to use the regional and local models that we have here in Connecticut as part of our national energy policy.

The first thing that we recommend is that you increase by 20 percent per year the energy efficiency budget for DOE. This is the minimum step that you have to take. We're talking about a program that is spending approximately $200 million a year, and yes-

terday, I understand, the savings and loan industry was the beneficiary of a $300 billion bail-out. Perhaps the war on global warming has been treated like the war on drugs in Washington, but perhaps some of the money from saving our financial institutions could be put into these areas so we could get that much more in the way of results.

The other thing would be to establish and mandate regional compacts to manage and coordinate energy efficiency programs and overcome regulatory obstacles which prevent us from carrying out energy efficiency programs. Northeast Utilities, which has the capability of delivering a lot of conservation potential, is somewhat stymied in that effort because to the extent that they free up capacity in Connecticut for export to Boston, they are not being properly paid for it. We should have a mechanism to overcome those obstacles beyond the mechanisms which are already in place; therefore, we call for Federal legislation which would establish and mandate regional energy compacts and associations among the States.

Again, I think you're going to have to use Federal funding as the carrot for that because most States are very reluctant to give up their authority in this area. If you had the carrot of additional Federal funding for involvement in a regional compact, it would be appropriate. You can use as a model the Northwest Planning Council which has done some very good things in this area on a regional basis in Oregon, Montana, Idaho, and the northwestern States. Again, their function has been somewhat stymied recently as well.

If I can just finish my recommendations, I will conclude.

The other is to remove Federal disincentives to energy conservation. As the Senator is well aware, the Internal Revenue Service recently announced that it was going to look at taxing energy efficiency investments made by utilities with consumers. That would absolutely be the worst signal that could possibly be sent.

The last is to create a national data base on the demand side management programs.

Finally, to enhance the role of the national energy laboratories. Much of the information that Armand Cohen referred to today came out of Berkeley Labs, which has worked hand-in-hand with our office and with the participants. But the problem is that what we really need is the presence of an energy lab right here in Connecticut, within the New England region, to work to develop these plans with the regulatory compact.

Finally, I would again thank you for your assistance with the Internal Revenue Service on this new policy declaring energy efficiency investments by utilities to be included as taxable income. It is one thing for the Federal Government to abandon an energy policy, but it is another thing to tax it to death. To coin a phrase, a famous Republican, Teddy Roosevelt, had the "Woodsman Prayer" that would be appropriate in this case. When the woodsman was being charged by the angry grizzly bear he prayed, "Oh Lord, please help me slay this bear. But Lord, if you don't help me, please don't help the bear."

I think that is appropriate with the Internal Revenue Service, so any help you can give us will be appreciated. Thank you.

Senator LIEBERMAN. Thank you, Jim. That was great. I thank you for your recommendations. As you know, we're trying to work with the Internal Revenue Service to keep the bear away from our door.

Before I go to questions, I gather that Commissioner Carothers is here. I wanted to welcome you and your deputy, Bob Warren. Thank you for attending.

May I say, as we are boasting—and in some sense, using the State example for what the Federal Government might do in this area—I gather that the Commissioner has just been part of an announcement, or will be part of an announcement today, that the northeast States together are going to adopt the California standards for automobile emissions, which is a great step forward. It is more than is required under the bill that the President has sent to Congress, the Clean Air Act, and I think it just speaks very well for what the States can do to lead us in environmental matters. Frankly, it just speaks very well for what will therefore be the increasing health of people who breathe the air here in Connecticut.

So congratulations.

Dr. Cagnetta, let me just start with you. On the surface of it, what NU is doing here is counterintuitive; I mean, basically you are involved in a program to sell less of your product. I want you to just tell us if you could, first, what you think are the factors that really got you into it. Was it pressure from the PUC? Was it internal concern about future sources of energy? Or was it something else?

Mr. CAGNETTA. Well, I guess it goes to the active discussions in the CL&P rate proceedings between the participants, conservation was a major issue. NU had what I will call the "traditional look" in resource planning by utilities. Connecticut Light and Power has surplus capacity, in the sense that we have sufficient capacity to meet our needs for the next 10 years, most of which is being sold short-term but will come back to us after the sale period so that we don't have to commit for new capacity in the short term. So there is no pressure to conserve. And with conservation, it brings a reduction in load—the load in which we already had committed capacity to serve.

So in a traditional look, yes, it would erode the earnings. It would erode the revenues, and it would create rate pressures. The solution to that has many elements to it. The first, in the regulatory area, we devised accounting techniques and forecasting techniques and accounting treatments so that expected revenues or revenue reductions will be accounted for in our revenue evaluation. So instead of going to an historical-type of accounting costs, we went to forward-looking accounting for costs. That helped in preventing the erosion of revenues that come about from conservation.

The second area is the area which Commissioner Boucher and Jim Meehan spoke to is concern over the surplus capacity that will be generated. Under the present situation, the prices that we would receive from other utilities would not be sufficient to cover our production costs.

Senator LIEBERMAN. Just for the record, can you give us a simple description of how that works? In other words, if we're conserving here in Connecticut, it seems obviously fair that we should enjoy

the benefits of that conservation. How does the pricing system work now when you sell excess capacity to other New England States?

Mr. CAGNETTA. Well, there are two mechanisms, both of which are not sufficient. The first of these is, by agreement—and these agreements go back 20 years now, when the New England pool was first formed. There was agreement with regard to what the purchase price would be for capacity if the utility was deficient and could not bring into place sufficient capacity in time to meet its own needs. A utility could then purchase through the pool, so the utility that had surplus capacity would provide it automatically. That price was based on a powerplant cost which was really not forward-looking but more historical, so it did not provide the coverage that we needed for our existing capacity.

Also, there are pressures from outside our region. There are utilities outside the New England region that do have surplus capacity, and they are ready to sell it short term at a price which is less than our production cost—that is, CL&P's production cost.

So there needs to be some prioritizing of what power should be taken first by the New England region. And if we have that, if that incentive is put into place, at least it will make CL&P whole.

Senator LIEBERMAN. What do you think of Jim Meehan's idea for a regional compact?

Mr. CAGNETTA. It would be very useful.

Senator LIEBERMAN. I am curious about how people within Northeast Utilities are reacting to this approach, which is an alteration of philosophy from what I'm sure people are used to.

Mr. CAGNETTA. Well, clearly there are people who go back 20 years, and it is taking a cultural change in the company to make them understand that growth is not necessarily good. There was a period of time in the 1960s and 1970s when our incremental cost for power was less than our average cost, so growth did not mean rate increases. So growth was good from the perspective of the ratepayer and growth was good from the perspective of the shareholder. That thinking and that culture are changing.

What they see now—and this is part of the benefit that our customer service people see—is that they are able to provide services that go beyond just the simple hookup of electricity or installation of a meter for a customer. They are now able to provide conservation and load management services not only to residential customers, but to large industries that had not taken all the opportunities for conservation. Our customers have been focused on their own production facilities and those capital investments. By making conservation services available to them, we are gaining a relationship with customers that is much stronger, the linkages are much stronger, and we are reducing their average costs of electricity, which makes their own products more competitive.

So our own people are now seeing the fruits of efficient use of electricity by our customers, and that's making them more positive about the acceleration of conservation at a time that we traditionally would not accelerate it.

Senator LIEBERMAN. How much awareness are you finding among your own people and your customers of the global warming problem? I understand you're not in the business of making judg-

ments, but is there any supplementary feeling that these programs are good because they're helping the global warming program? Has it broken through people's consciousness?

Mr. CAGNETTA. On a secondary level, I think it has. I think the primary focus in business is competitive survival—not only nationally but globally—and the issue of global warming, in their perspective, is an international issue. Although they may deal with it and think about it, I don't think it's a primary motivation for them at this time.

Senator LIEBERMAN. Mr. Cohen, I appreciate the positive statements in your prepared remarks and what you said earlier about what we find here in Connecticut. From your perspective, what are the two or three most important steps that the Federal Government could take to encourage conservation of energy?

Mr. COHEN. Well, I think Jim pretty much outlined the same kinds of steps we would take.

I want to emphasize the R&D component. I didn't bring the high efficiency ballast to show you, but that technology was essentially commercialized, brought to commercial production, by the Lawrence Berkeley Lab, and that's a very significant development.

I guess, given the "White House effect" as Jim called it, and the negative kinds of signals that have been coming from Washington, I tend to think that the States are going to be taking the lead. But one suggestion I might make is that the learning from New England might possibly be incorporated into national legislation. For example, there could be a broad mandate to utility commissions that haven't been as progressive and far reaching as New England's commissions to force utilities to undertake the kinds of programs that CL&P has voluntarily agreed to undertake. So there is sort of an "export from New England" function that congressional legislation can play a role in.

I guess, finally, the Federal Government does pretty well at information transfer. One of the roles that an expanded or beefed-up national lab system could play is transferring the hard measured data that we get from these programs, transferring it elsewhere so that advocates and utilities around the country can see it.

Oddly enough, there haven't been any really rigorous measurements yet of what large-scale energy efficiency can do across a broad spectrum of buildings. People have been doing it for a long time, but the data base isn't really there to support this kind of activity in other parts of the country.

I hesitate to really spell out a much more detailed role for the Federal Government because I think we're all at a learning stage on this, but I would say primarily, information and R&D.

Senator LIEBERMAN. I appreciated what you said when you were speaking about the fact that this is obviously going to go on, that some of the same policies that we talked about in the 1970s as a reaction to the oil price rise now come back and have a double impact, which is that they are also a reaction to a global warming problem. I think it's important to remember that, that even as there is some skepticism about global warming—although I think the scientific evidence gets stronger and stronger that it is happening—there is still an energy efficiency payoff here for us if we

adopt these same kinds of policies. It's too bad we lost some of the time in between.

Mr. COHEN. I think it's very unfortunate. As Rafe mentioned earlier, after a period of steady decline, over the past 15 years, in energy input per unit of GNP in this country, we're beginning to tick back upwards; that is, we're beginning to get in that lockstep where energy use is again coupled with GNP growth.

Senator LIEBERMAN. Yes. I noticed the 1987 number that Rafe indicated. Why is that happening? Is that just that people are going back to some old ways, or some more products?

Mr. CAGNETTA. Well, in my own mind it is the overall performance of the economy, but second is the price of energy. Oil prices have fallen enormously, and consequently we have accelerated our use of energy. The price is an essential component of the whole question; the higher the price, it triggers greater investments and alternatives in conservation. So price is an important aspect of this.

Mr. COHEN. Sir, I just wanted to remark on the issue of environmental benefits. Everything that I have talked about this morning and that we have all talked about in terms of energy efficiency can be justified on conventional engineering economics as if the environmental problems didn't exist.

We can go much further than that if we begin to value that avoided CO_2 or that avoided sulfur dioxide. Tying into your question about national legislation, one of the interesting effects from the legislation that created the Northwest Power Plan that Jim Meehan referred to is that Congress mandated that when conservation investments are being considered by a utility in comparison to a supply option, that the conservation be credited with a handicap, if you will, that would favor it, to account for environmental benefits. So you aren't just comparing out-of-pocket dollars.

I think that's another good thing to be written into national legislation. It is being pursued here in the region now, but I think a good swift kick from the Federal Government would move that process along.

Senator LIEBERMAN. Peter and Jim, again I congratulate you. I wonder if there is anything from a utility regulatory point of view that could be done further to encourage the use of renewable sources of energy.

Mr. BOUCHER. I think we have taken some steps here by way of the adoption of regulations that permit nontraditional players to get into the process of both providing supply side resources, as well as demand management resources. And from the supply side, the regulations that we have recently adopted permit those nontraditional players. People who have expertise in nonrenewable resource technologies are able to come in and play the game, so to speak, in terms of providing technologically sound renewable resource fuel supply side options. That's certainly one area we can look to.

The traditional regulatory framework has had to shake out some of the cobwebs and permit the intervention and participation by nontraditional players. That is happening on transmission as well to some degree, and certainly in the generation area.

We have also adopted, as I've indicated, the regulations on conservation bidding, where nontraditional players—and we certainly don't want to exclude Northeast Utilities or one of its affiliates from getting into the conservation demand management service-providing industry—but we would like to have anyone and everyone get in and have an opportunity to provide those services to any who can benefit from them. Again, there we have attempted—and it's really a little early to see how successful we're going to be—to institutionally accommodate new players in that area, as well.

I think that with the collaborative effort, one of the biggest steps in that process has yet really to u[illegible] and that is the process of demonstrating empirically the level [illegible]ccess that all of the various innovative programs are achieving, or have achieved, or will achieve. I think once we've gotten down that road we'll be in a much better position to make more widely known and understood to the consumers, whether it's Pratt & Whitney or whether it's the housewife or househusband, that there is technology in the form of that light bulb that should be available in the hardware store, and it has been proven, not something that is fragile or otherwise speculative in terms of whether it is going to pay out over the course of its useful life.

I think once that documentation or demonstration of what's available becomes more widely known, I think we're going to have more penetration and a greater level of success.

Mr. MEEHAN. One thing that I think you and the members of your committee should be concerned about is the Public Utility Company Holding Act, which Mr. Cagnetta referred to; it is coming up for debate. What we see coming from Washington is the greatest amount of debate in the electric utility industry now over who is going to build the next generation of machines. It is going to be more competitive; who is going to be the one to build the new power plants? Basically, that's where all the money is going. People are speculating about unleashing the electric utility industries and letting them compete fairly with the independent power producers to build new plants.

I think that focus is wrong. The focus there, again, is on building and production. I certainly would support and use efforts to have PUCHA reform if they want to get into the energy service business, because I think they could do that well. They are probably one of the few major institutions in the country who have had some great experience with it, and we ought to let them get into it. I'm not sure we want to expand the Public Utility Company Holding Act in order to let people build new cogeneration machines or machines in Texas or anywhere else around the country. Again, I think you have to be concerned about where the dollars are going and where all the money in Washington is going to lobbies. You will see that a lot of people are involved in this independent power production issue. You don't see many people down there fighting for energy service companies or conservation services or efficiency companies because the dollars have not gotten behind those types of efforts.

I think it should give Congress cause for concern when they approach this Public Utility Company Holding Act debate and the independent power producers; are we just unleashing some forces to

build new power plants? Is that all we need in this country, or do we need a redefinition and a refocus on the efficiency side? Perhaps you ought to give them incentives to get into the efficiency business and disincentives to expand the production and construction of a new generation of power production facilities.

Even here in Connecticut we went into this more competitive marketplace. What we got was a lot of woodburners. We got a coal plant. We got a number of gas-fired machines that people say are better; arguably they are. But I think if we took half those dollars that we're going to put into cogeneration into new production, and put them into efficiency, we would have gotten twice the amount of capacity out of them and it would have been much more environmentally economic. All you need to know—and the State legislators know this better than I do—in their towns when they are trying to site some of these power plants, which are seen as soft energy, you ought to see the 600 or 700 people who show up at public hearings and say, "We don't want that soft energy in our back yard."

So the tone in Washington is about what people are pushing for, because they are really pushing to build the new—again, it's just a different way of doing it. The regulation would not be as severe with as great a profit margin as independent power production, but I think the focus is wrong and we ought to try to stop that now.

Senator LIEBERMAN. Let me tell you one thing we're hearing in Washington and ask you to respond from your perspective, and that is that the global warming problem which we're focusing on here this morning should lead us to take a second look at nuclear power, and perhaps at the development of smaller and hopefully safe nuclear power stations because there's no global warming effect from nuclear power.

I'd like to invite some reaction from you on that.

Mr. MEEHAN. I think that the development of technology is probably appropriate for research purposes. We do have nuclear plants; they are going to continue to operate, and things that you learn in that area are appropriate.

Connecticut, I would have to say, with 70 percent of its generation coming from nuclear power—the last thing they need, even if it's a super-duper "kick the tires" best model off the block, the last thing we probably need is that in our energy mix at this time. But development of the technology might be appropriate.

I think you have to be concerned, though, whether the technology is going to catch up—the ability to produce those plants—will ever catch up with the nature of the technology that you have to be concerned with.

Mr. CAGNETTA. I think that the first priority should be conservation technology. In fact, what I've seen in the Department of Energy's statements about their energy plan today, there clearly is more focus on supply than there is on demand, and I think there needs to be a balance.

There is research to be done on conservation technology, and there is a lot of commercialization that needs to take place, which the Federal Government could also help bring about. So the first priority should be conservation.

As far as modification of the Public Utility Holding Company Act, what we're saying is that if it is going to be changed, make it equitable for all the players. We're not proponents of a change to the Public Utility Holding Company Act, but if a change does come about, make us a player not only in cogeneration but in conservation services. Keep us from being restrained.

As far as nuclear power is concerned, Jim's intuitive feeling about having enough nuclear power from a technical standpoint and a planning standpoint, we agree with. When you look at baseload capability, the extent of nuclear power that we have today in our system—our mix—is sufficient. It is an optimum design. In fact, we will probably maintain about a 50 percent nuclear capability for the next 5 or 6 years, and that's about where it should be.

As far as whether nuclear capability should be developed further, it is the only technology that is "in the horizon," so to speak. Obviously, solar has a potential that will be developing, and we should support it. Fusion is much further out than advanced fission techniques.

So if we're thinking about a technology for the first decade of the 21st century, the one that it is at least near in hand is the advanced fission designs. There clearly are efforts going on to make it inherently safer, but I think there needs to be a national energy plan to make the public understand better the technology risk, because every social study that I've seen, either at Yale University or at other prestigious universities that have taken on social studies of perceptions of risk, the nuclear risk is clearly well above what it realistically is in the minds of our public. With every event that occurs, whether it's Chernobyl or whether it's Savannah River problems, that just makes the situation much worse.

So I think that hand-in-hand with technology development there really needs to be some significant public education on nuclear power.

Mr. COHEN. Senator, I would just like to add to that from an environmental group's perspective.

I think it would be irresponsible to rule out any option. I think we are open-minded on that. To my mind, it's an issue of timing and cost. This is here today; it's about $500 per installed kilowatt. The most optimistic estimates of the new wave of reactors come out in the $1,500 to $2,000 per kilowatt range. It's a very cheap, very quick solution, and I think a way to see it is as a bridge toward the time when we can get into the more benign generation-side technologies.

Let's recall that nuclear power came into being through a very conscious set of policy decisions and public subsidies that brought it to commercial operation, and I think if a similarly large effort were made on the solar side, we would see that option become technologically feasible much more quickly.

Senator LIEBERMAN. Well, I appreciate the contribution of this panel and I thank you for your time. Again, I thank the people of Connecticut for leading in this area. I wish you well, and I hope we can work together to see if there are ways we can make it easier for you.

One of the things that I've been committed to in the little more than a half year that I've been in Washington now is to try to fight

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for more Federal support for research and development in conservation technology, energy-efficient buildings, and energy-generating options that are environmentally attractive.

I am going to exercise the prerogative of the chair and suggest that we have a 5-minute recess, and then we'll come back to the last panel.

[Recess.]

Senator LIEBERMAN. Welcome back. Thank you all. I appreciate the attendance of everyone here who took the time to be here and hope that you are enjoying and benefiting from this as much as I have been.

We turn now to what we are generally calling "environmentally attractive options for generating energy," which we go back to now because of global warming, as well as energy concerns. I approach it also from the point of view that there is tremendous economic potential here for Connecticut and for the United States if we can develop sufficient capacity.

I read an article a couple of months ago that bothered me a lot. I've forgotten whether it was the New York Times or the Wall Street Journal, but it said that solar energy technology, which had really been pioneered here in the U.S.—a lot of the important work had been done here—was now at a point where it was commercially viable. And just at this moment, some of the major companies involved in it in America were pulling out. You will not be surprised to hear that some of the other leading players in the world economy, particularly Japan and Germany, are getting into it more deeply, or even into it somewhat.

My concern, naturally, is that the worries that we have about global warming and energy shortages are shared worldwide and they're going to be shared increasingly over the years because, as we've said, by definition nonrenewable energy is going to run out at some point. It's nonrenewable.

So I look forward now to hearing these gentlemen from the private sector who are working on some exciting developments and alternatives as to what you're working on, and also what the Federal Government can do to help you and, in that sense, to help America remain economically competitive. Not only that, but hopefully we can be the real economic leader in this field.

The first member of this panel is Roger Little who is, I gather, technically representing the Solar Energy Industries Association; he now runs a business in Boston, I believe, involved in alternative energy. Maybe you should first just introduce yourself briefly, and then we'll look forward to your testimony.

STATEMENT OF ROGER LITTLE, SOLAR ENERGY INDUSTRIES ASSOCIATION

Mr. LITTLE. Thank you very much, Senator. I am Roger Little, and I am part of the Solar Energy Industries Association. I am also Chairman of the Board of US/ECRE, which is the Export Council for Renewable Energy. I am the President of Spire Corporation; we are in Boston, a small business that principally works in the photovoltaic field. Although I do represent the renewable energy indus-

try, my expertise is really in photovoltaics, so you will probably hear a lot more about that.

The points I want to make are that, yes, renewable energy can help with global warming. It can displace significant amounts of CO_2, both in this country and internationally, especially where three-quarters of the world's population does not have electricity. That's a big number. If you go to countries like China and India, they are burning off their forests to produce the energy they need to try to raise their standards of living. So export of renewable energy technology can be of significant assistance.

We can have an impact in the developing world. In the United States, renewable energy can be more expensive; even though, at least in photovoltaics, costs are coming down as production is going up. We need to encourage international markets to get our production volume up in order to be more cost-effective.

And no, we are not doing enough in the U.S. to promote renewable energy. I think the DOE budget was one example we cited as being tremendously useful. Before it was cut drastically.

So with those points I wanted to make, I thought I would use a few slides to try to go over——

Senator LIEBERMAN. Let me ask you this, and maybe it's answered on the slides. It's a primitive question, but what are photovoltaics, for the record?

Mr. LITTLE. Photovoltaics are the conversion of sunlight directly to electricity. You do that through a semiconductor-based technology. One square yard of sunlight has 1,000 watts of electricity. Photovoltaics has the ability to convert about 10 to 15 percent of that sunlight to electricity. So we're talking about 100 watts per square yard and about one-half megawatt per acre.

Senator LIEBERMAN. Okay. And these are the screens that we see, that we think are solar energy. Am I correct?

Mr. LITTLE. What you see on houses can be solar heating for hot water. In fact, I've got a micro-utility plant for viewing here today which is photovoltaic. You put it in sunlight—I can put it in light up here, and it will play an important solar song.

But that's a semiconductor device which, when the sunlight shines on it, makes electricity. Most of what you see on homes are solar thermal; they heat the water.

Senator LIEBERMAN. Okay. I'm going to pass it around.

What's the song?

Mr. LITTLE. Well, you have to put a bright light on it or take it outside. I've forgotten what it is.

Senator LIEBERMAN. Okay.

Mr. LITTLE. That's a solar cell that we make. It's a semiconductor device. Sunlight shines on it, and out comes electricity. It's like a short, flat battery. It only provides electricity in the sunlight.

[Slide.]

Here's New England Electric. They have lots of sources of energy——

Senator LIEBERMAN. New England Electric?

Mr. LITTLE. The utility.

Senator LIEBERMAN. Where is that?

Mr. LITTLE. Up in the Boston area.

Senator LIEBERMAN. All right.

Mr. LITTLE. They see that their existing capacity, including hydro from Quebec, is okay, if we have only 1 to 2 percent growth in electricity demand. If we go above 2 percent, there is a tremendous shortfall. I think this represents a lot of the utilities in the country. Although we don't talk about some of these renewables for base level electricity, the ability to make a contribution in this percent shortfall area is there.

Senator LIEBERMAN. Is 2 percent a likely growth rate?

Mr. LITTLE. No, 2 percent is a very low estimate of what we're experiencing. It's more like 4 to 5 percent.

Senator LIEBERMAN. So left on that path, there would be brownouts and blackouts?

Mr. LITTLE. You've got it. Yes, sir.

[Slide.]

This is a utility in California that is using photovoltaics. They have put on a grid in California a whole array of photovoltaic modules. This is producing 6 megawatts. There is almost no maintenance, and clearly, no CO_2.

Senator LIEBERMAN. It is economically efficient?

Mr. LITTLE. It is economically efficient. But, I will show you, that we are still a factor of 4 too expensive compared to other utility options.

[Slide.]

Before I show that, however, Boston, which has a more diffuse sunlight, is not that different than Albuquerque in terms of the ability to use solar energy. So that would apply also to Hartford. Solar energy is effective in this neighborhood.

Senator LIEBERMAN. That's a very important point. In other words, we would ordinarily think that it would be easier to use solar in California or Albuquerque than here, but that's not the case?

Mr. LITTLE. If you will look at this chart, you can see by the bars on the right-hand side, where they are separated, that it's a only 20 percent effect.

Senator LIEBERMAN. But it is still usable here?

Mr. LITTLE. Yes, sir. Because even though it's cloudy, you get a lot of solar energy shining on the surface.

One major thing that's happening, as we know and as was mentioned before, is the price of oil is rising. I have recently seen projections which show it will be back to the 1981–1982 price level soon. I think we've all seen those. That's going to have a big effect as to how competitive we can be with renewable energy.

So it's coming, but how quickly it comes is really a big question.

Senator LIEBERMAN. Are people making money in this business today?

Mr. LITTLE. In photovoltaics, we are not making money. But the business is growing at 30 percent per year; it is a $500 million market from an international point of view. So you're talking about a $500 million business growing at 30 percent per year, dominated by some major manufacturers. One is ARCO; another is AMOCO. ARCO recently has been purchased by Siemens. This is something that——

Senator LIEBERMAN. The German company?

Mr. LITTLE. Yes.

[Slide.]

This is an example of photovoltaics' ability to meet these needs. As I mentioned, something like three-quarters of the world doesn't have electricity. This kind of array could provide enough electricity for a village of a thousand people. This is a great way to deploy photovoltaics and affect global warming on an international scale.

[Slide.]

Here is one of our problems. I show the PV funding budget for DOE. This is for R&D for advancement of the technology. You can see that it peaked out in——

Senator LIEBERMAN. PV is for——

Mr. LITTLE. Photovoltaics.

You can see how the DOE budget has varied over the past few years. Incredibly, it has leveled at about $30 million.

So we need to do two things, then. One is to get the volume of production up, which we can do by encouraging utilities and others to use it; and two, improve the technology through this budget.

So that's just to give you an idea of what can be done with renewable energy.

Senator LIEBERMAN. Thank you. I appreciate it.

You made a very important point, which is that one of the concerns that I know people have about how the world is going to go after global warming is that in many areas it is going to be hard to get the developing countries to do what we feel they should do, because they will say, well, why don't we have the same right to develop our society the way you did? Why do we have to sacrifice?

But I think what you're suggesting is that in this area at least, where there is no electricity for three-quarters of the people in the rest of the world, that this is an opportunity to build from the beginning a generating capacity that has no negative effect on the global warming problem and still satisfy the need for electricity.

Mr. LITTLE. Yes, sir. That's it.

Senator LIEBERMAN. To what extent are photovoltaics being used as a generating source in Connecticut or in New England today?

Mr. LITTLE. New England Electric has a major project, but it is experimental because they have to go according to cost comparisons as well. They have a major project in the Worcester area where they put photovoltaic modules on 30 houses and took all that electricity and tied it into the grid, so that during the day when the Sun is really out, they essentially buy the electricity from the homeowners, who aren't using it, and sell it to industry. In the evening, the reverse is true. So each home becomes a small utility plant.

Senator LIEBERMAN. That's great.

Mr. CAGNETTA. Senator, in the last 2 or 3 years we in Northeast Utilities have been taking solar readings and gathering solar data so that we can make some realistic judgments as to cost of power from solar technology. We are, through the Electric Power Research Institute, supporting continued research development on photovoltaics and other options.

From the data that we've gathered over the years and the application engineering studies of photovoltaics, at least today, the average cost is in the range of about $0.15 to $0.20 per kilowatt hour for the technology as it is today, whereas our average production

costs for our present system are about $0.06 per kilowatt hour. So that gives you a range of what needs to be achieved.

There needs to be some technological gains, but some tax incentives might help the situation.

Senator LIEBERMAN. I agree, obviously. If we just do it on the balance sheet it's going to take a while, but there are other societal and environmental factors that even that out a little bit, and we ought to try to express that. Probably the best way is through the tax system.

So you would say that right now Northeast Utilities, as one company that obviously has a major impact on Connecticut, is some distance away from using photovoltaics as an energy source?

Mr. CAGNETTA. Yes. But from the studies we've seen, as was referred to in the Southwest where the Sun intensity is greater, the $0.15 to $0.20 is probably more like $0.10 to $0.15.

Senator LIEBERMAN. Yes. That's closer.

Mr. CAGNETTA. If their average production costs are a little bit higher, in the area of $0.07 or $0.08, the margin now comes closer together. Tax incentives could reverse the situation.

Senator LIEBERMAN. Okay.

Thank you, Mr. Little.

Mr. LITTLE. Might I just add one thing?

Senator LIEBERMAN. Sure.

Mr. LITTLE. We sell equipment that manufactures these. We do not sell these. Right now our business is pretty good, and it's mostly to Japan and Europe where they are scaling up production.

Senator LIEBERMAN. There is more consumer and market interest in Japan than there is here?

Mr. LITTLE. There is more interest in Japan and Europe for manufacturing modules for sale on an export basis, as well as in-country, than there is in the United States.

Senator LIEBERMAN. Why?

Mr. LITTLE. Well, I think they see a little further ahead than we do, but also their governments are really pushing the technology forward, especially in Europe as a result of the nuclear problems they've had. The Japanese see it as an export market.

Senator LIEBERMAN. How are the European governments supporting this movement, do you know?

Mr. LITTLE. Yes. Their budgets—I know that West Germany now has a budget that is equivalent to our DOE budget, just in West Germany. France has more——

Senator LIEBERMAN. For what?

Mr. LITTLE. For solar energy. So they are pumping up the Federal budgets to develop the technology and to cost-share the fielding of systems to show that it works.

Senator LIEBERMAN. Okay. That's alarming.

Don Glenn is Vice President of Energy Research Corporation, ERC, in Danbury. Don, it's good to have you. Tell us what you're up to.

STATEMENT OF DONALD R. GLENN, VICE PRESIDENT, ENERGY RESEARCH CORP., DANBURY, CT

Mr. GLENN. Before I do that, Senator, I think we ought to give you our gratitude for the courage that you have shown so far, to take on this type of a challenge during your first term. It is a long way off before you see the gratification of the work we're going to be doing, and we hope you stay in Congress long enough for that to happen.

Senator LIEBERMAN. Thank you. I learned from my years in the Connecticut Legislature that one ingredient—you need two ingredients. One is goals in the Legislature, and the second is patience.

I'm going to try to have both, but not too much patience.

Thanks for what you said.

Mr. GLENN. In my formal statement I've developed some amount of detail on some of the key points that I will try to cover very briefly here, and hope that I beat Don's bell.

I know you were in Norwalk yesterday and you saw waterborne wastes and some of the mess that creates, which may even have a more immediate public perception of impact because it is something physical. It's not quite as intangible as looking at smog.

That is locally controllable; air quality is not locally controllable, as we have heard earlier. In New England, the air quality problems are mainly caused by our western-located neighbors. They represent the industrialized States, for the most part, in the United States. When I say the northeast quadrant, I would refer to anything east of the Mississippi.

So there is not much we can do as a State about those things except act in the Federal family to make sure that the country itself adjusts properly, and vote in the right direction on those issues.

However, as was also mentioned earlier, when you're down at this level of the panel you hear most of your points made already. The energy situation in the State and in the region is very definitely locally controllable. We do have a sense of destiny that we can manage.

For my answering of the testimony challenge that was given to us to appear here, I tried to cull out a picture of the New England and Connecticut situation, and during the break I made sure I wasn't going to tell any lies by checking it out with the panel.

I understand that the capacity reserve margin, which is a measure of how much extra capacity you have to meet peaking conditions, is going to be the lowest in the United States in the New England area starting in 1993. It will be down to well below what the reliability requirement is for utility regulation of capacity reserves.

This area at large depends on high-cost fossil energy to the tune of about 50 percent of the total generating capacity. Certainly, that will be the case in coming years. Most of that is oil, imported, and the rest of it is natural gas, which is also "imported" from the south. At the end of those pipelines, you are paying the highest cost for those fuels; therefore, the desire to use them more efficiently or to reduce their use by switching to something cheaper would be in order.

The other interesting fact which I came across is that we in this area may be the second largest importer of electricity, second to California, by the time the decade rolls by. That's probably a very precarious position for us to be in. What it has by way of impact is that industry can desire to relocate, and population can also follow industry when you're paying too much for energy and you don't have the quality of environment that people are seeking. Certainly, the trend in that direction is showing up even today with southern migration of populations.

That's my story on where I think the scenario is.

ERC is a company that is solely devoted to developing technologies for utility load management in the way of batteries for leveling the peaks, and fuel cell technologies, which I'll spend much more time on in this dialogue.

Fuel cells are, in fact, the most efficient generators ever built by man, and probably the most efficient that will ever be built by man, certainly in our lifetimes and our children's lifetimes. The reason is that they are frictionless. They have no moving parts and they operate like a battery. You can expect, in times of mature mass production, electric efficiencies of total systems in the 60 to 70 percent range.

Senator LIEBERMAN. Maybe you're going to do this again, but for all of us so that we can see it, what's a fuel cell? How is it used?

Mr. GLENN. A fuel cell could be thought of as a black box that would be a big version of a battery—most everyone knows what a battery physically looks like—except that it operates at a temperature, and it needs to do that in order to convert hydrogen into electricity through an electrochemical conversion process.

Senator LIEBERMAN. So what goes into it is hydrogen?

Mr. GLENN. Hydrogen, and hydrogen can be in the form of a fossil energy-derived gas, such as natural gas, or coal gas, or renewables—biomass certainly is in that game plan, from landfills or from anaerobic digesters, say, in municipal waste treatment facilities; or directly from hydrogen produced by electrolyzing sunlight—in other words, electrolysis, which in the simplest sense gives you hydrogen and oxygen out of that electrolysis process. Of course, hydrogen is considered the ultimate fuel in the centuries ahead.

Senator LIEBERMAN. Right.

Mr. GLENN. So fuel cells represent a technology that can take us from today into the future.

Senator LIEBERMAN. And what it produces is——

Mr. GLENN. D.C. power.

Senator LIEBERMAN [continuing]. D.C. power——

Mr. GLENN. Which then can be converted to A.C. power if desired.

Senator LIEBERMAN. Right. And it uses less of the input energy?

Mr. GLENN. Because it is more highly efficient, it uses more of the energy value of the fuel coming in, and therefore produces less wastes as well. Because it is using it more efficiently, you do have less carbon dioxide; and in the case of the nature of fuel cells, not being a combustion process, you don't form acid rain precursors, or a very, very little amount of it.

Senator LIEBERMAN. But at what order of magnitude does it produce less CO_2 than what we're using now?

Mr. GLENN. Upwards of 50 percent less than current conventional generation systems.

Senator LIEBERMAN. Okay. Sorry to interrupt you.

Mr. GLENN. Some of those numbers, by the way, are in my testimony.

Senator LIEBERMAN. Okay. And the potential use here is, again—for instance, to sell it to Northeast Utilities?

Mr. GLENN. Well, certainly, we would hope that the utilities would—and I know that EPRI, as a representative of the utility structure, is very aggressively, within their funding constraints, supporting fuel cell development.

Senator LIEBERMAN. But I presume that the cells also could be sold to independent users?

Mr. GLENN. Yes, indeed.

Senator LIEBERMAN. Large ones like a factory or a shopping center?

Mr. GLENN. We see fuel cells able to do missions, starting out in the truck/van/bus-sized vehicles and the land (stationary) equivalent, in terms of power ratings. A bus is about 50 to 100 kilowatts of power equivalent; it certainly has stationary generation potential in those ranges, all the way up to hundreds of megawatts when used with natural gas or coal gas.

Senator LIEBERMAN. So they can be used to power vehicles as well?

Mr. GLENN. Yes. There are technologies that would seem to be attractive, given the chance——

Senator LIEBERMAN. I interrupted you. Why don't you tell us where ERC is and where the product is at this point?

Mr. GLENN. ERC is currently siting for a manufacturing facility for our advanced molten carbonate fuel cells, which would use natural gas directly. The plant will produce high-cost first units, but they will justify going to a mass production facility sometime in the 1994–95 time frame. So we will be entering into the demonstration phase in 1992 with the technology in the hundreds-of-kilowatts size, and in 1993–94 to the two megawatts and up size range. That will be followed by sales in the marketplace.

Senator LIEBERMAN. So you are not selling at this time? This is all R&D at this stage?

Mr. GLENN. Yes, late development. We're really in the very last phase, which is also the highest cost phase of the program.

Certainly, the bottom line—and I'm going to have to get to the bottom line quicker than I expected—is that with respect to the legislation that has been near and dear to you, and you've done a marvelous job of trying to recognize these technologies in that legislation, the legislation does need to cite fuel cell-derived power. We don't hear it from the utilities that that is an option they think of, first off, and I really don't understand that. I'm digressing from my prepared statement.

Senator LIEBERMAN. That's okay.

Mr. GLENN. We do need to have an appropriate incentive program to allow higher first cost units to get their chance to shake out, so that mass production facilities—we will capitalize, but we need to know that there is a market that will buy them.

We need to reward pollution reduction attainments beyond new source performance standards. They are artificial. You should reward people for however much reduction they can get, proportionate to that reduction, whatever the level is.

I think you need to recognize that there is a balanced energy policy required. We have a lot of pro-coal folks, particularly in the eastern part of the country, who also dominate the right committees in Congress. We need to recognize natural gas and, if necessary, some amount of oil from the domestic suppliers, as viable options in the future energy policy.

Finally, we do need to place R&D funding priorities on high efficiency, low polluting technologies that are crying for a chance to be tried. We don't see that yet.

Thank you.

Senator LIEBERMAN. Thank you. Thank you for what you are doing.

Next is Dr. Warren Chernock, who is Vice President of Combustion Engineering in Windsor. It is an interesting twist of fate, I suppose, if you have a very positive concentration of corporate interests here in Connecticut in alternative and renewable energy sources.

Dr. Chernock.

STATEMENT OF WARREN P. CHERNOCK, VICE PRESIDENT, COMBUSTION ENGINEERING, WINDSOR, CT

Mr. CHERNOCK. I would like to thank you for the opportunity to discuss the impact of fuel cells on the energy requirements and environmental concerns of this Nation.

Currently, more than 500 C-E designed coal-fired utility boilers and 15 safe C-E designed nuclear plants are in operation in the United States.

Combustion Engineering is an energy company. As such, we believe that fuel cells can be an important component of new energy sources which are more environmentally benign.

The gasses which are believed to be the major contributors to the greenhouse effect are carbon dioxide, methane, chlorofluorocarbon, and oxides of nitrogen and sulfur, commonly referred to as NO_x and SO_x. It could take at least 20 years or more to determine whether global warming is real.

We are not an advocate of a wait-and-see policy, especially when an apparent win-win situation presents itself. It is our opinion that reemphasis on nuclear and the development of fuel cells by DOE represent actions which can and should be actively pursued to assure electrical energy sources for this Nation using technologies which are more environmentally benign. Should the greenhouse effect be real, this approach will help to mitigate its consequences. Should the greenhouse effect be a false alarm, this approach will still be of value to the public via increased utilization of energy sources which are more environmentally benign. This is, in fact, a win-win situation.

Conversion efficiencies for fuel cells range from 40 percent to 50 percent, in contrast to approximately 35 percent for coal and nucle-

ar power plants. When using natural gas as fuel, fuel cell efficiencies in excess of 60 percent are possible.

The molten carbonate and solid oxide fuel cell concepts being developed by C–E operate at 1,200 degrees Fahrenheit and 1,800 degrees Fahrenheit, respectively. Hot gaseous byproducts and unused fuel can be used to power combustion turbines and waste heat boilers to improve overall system efficiencies by at least 10 percent with such bottoming cycles.

The Public Utilities Regulatory Policy Act has stimulated a return to local, on-site cogeneration. This cogeneration market is expected to expand. Fuel cell systems appear attractive for this area.

One of the most promising coal-fired advanced power generating technologies is the coal gasifier/molten carbonate fuel cell which can be used for both new facilities or to retrofit old power plants to increase their capacity and improve their environmental performance. A system to retrofit an existing power plant can result in a 99.95 percent reduction in SO_x and an 83.8 percent reduction in NO_x. These systems have been designed for new power plants with an efficiency approaching 55 percent, resulting in a 42-percent decrease in fuel consumption and, importantly, a 42-percent decrease in carbon dioxide emissions.

Thus, upon successful completion of development and demonstration programs, introduction of fuel cells can provide another means for utilizing our vast coal and natural gas resources to generate electricity, while at the same time reducing the amount of CO_2, SO_x, and NO_x emissions. This will have a positive impact in reducing global warming if in fact it is real. In addition, should President Bush's proposed clean air legislation become enacted, fuel cell systems, with their inherently lower gaseous emission characteristics, will become more prominent candidates as sources for electric power generation.

Continued DOE support for fuel cell development is necessary, especially in view of the long lead time before commercialization. The molten carbonate fuel cell is expected to be commercialized first, around the mid-1990s, because of its advanced stage of development relative to the solid oxide fuel cell. Initial commercialization is expected for natural gas-fueled cogeneration applications in regions of the country where siting may be difficult for new base load generating capacity.

Higher gas prices are likely to promote coal gas, with its attendant gasifier technology, now under advanced development. This fuel is expected to stimulate larger sized molten carbonate units for intermediate load following at central power sites and for repowering coal units now located in populated areas as a consequence of urban sprawl, to low BTU gaseous fuel, operated in parallel with a back-fitted molten carbonate fuel cell and coal gasifier. This conversion can essentially double power output, virtually eliminate SO_x and NO_x releases, and enhance overall efficiency about 10 points, while at the same time combatting global warming.

The solid oxide fuel cell is viewed as a follow-on to molten carbonate for natural gas-fueled applications such as residential and

industrial complexes, and for vehicular propulsion such as urban mass transit, off-road vehicles, and perhaps shipboard propulsion.

Because scale-up of molten carbonate fuel cell systems is underway by the three DOE contractors participating on this panel, each of whom is pursuing this objective on a different design basis, we believe that it is inappropriate to select a single approach at this time, but to fund each of these three contractors at a level of about $8 million a year for fiscal year 1990. In this respect I would like to thank you for your efforts in supporting the fiscal year 1990 Senate appropriation of $18.4 million, which now must be resolved via conference with the House appropriation of $15.4 million. Your continued support of the Senate funding level is sincerely appreciated.

I would like to thank you for the opportunity to appear before this subcommittee. Hopefully there will be a question or two on nuclear, which I had hoped to address earlier, but let me just take a moment. There have been many comments made on nuclear today. I would just like to add one or two of my own.

It is safe. There are no CO_2, NO_X, or SO_X emissions. Nuclear generates electricity safely and economically, with no global warming effects. Environmentalists are recognizing the benefits of nuclear, and I solicit your support also.

Thank you.

Senator LIEBERMAN. Thank you for your testimony. I was delighted to be able to figure out the process enough to be able to work with the Interior appropriations subcommittee, headed by Senator Byrd, to make sure we could get that $18.4 million in. I assure you that we're going to work to support the work that is being done here, and I assure you that Senator Dodd and I are going to fight hard to make sure that it stays in after the conference report.

Mr. Bill Lueckel is Manager of Government Programs at International Fuel Cells, which is located in South Windsor.

STATEMENT OF WILLIAM J. LUECKEL, JR., MANAGER FOR GOVERNMENT PROGRAMS, INTERNATIONAL FUEL CELLS, SOUTH WINDSOR, CT

Dr. LUECKEL. I will start out by thanking you very much for the opportunity to speak about the environmental merits of the fuel cell. Just the fact that someone cares enough about the contribution of fuel cells is so different from what we have seen in the past, is truly amazing. We really do appreciate this opportunity.

We are in a little different position than either ERC or Combustion Engineering because we have passed through the R&D stage. We are out selling a clean fuel cell power plant in the marketplace now.

Before you ask the question of whether or not we are making money, the answer is no. I didn't want there to be any fuzziness about that.

Here is a picture of the very first IFC 200kw on-site fuel cell power plant. Senator, you saw this when you and EPA Administrator Reilly visited IFC in April 1989. That power plant is now at a utility site. As a businessman, I am tremendously excited about it; but as a U.S. citizen, I must tell you I am disappointed because

that location, that site, is not in Connecticut or even in the United States. It is in Japan.

Senator LIEBERMAN. Is that because they're willing to spend a little more money up front?

Dr. LUECKEL. A lot more money up front.

Senator LIEBERMAN. Because obviously you're at an early stage of development, so it is not competitive.

Dr. LUECKEL. Right. I could tell you—not for this particular machine, but for a previous larger fuel cell power plant—that we couldn't get the U.S. utilities to pay $3,000 a kilowatt. The Japanese paid $7,000 a kilowatt and then they said, after we do that, then we'll work on how to deal with the economics. It's a different attitude.

I want to show you some of the emission data that accompanies these power plants. I don't have time to go through all of the details, but since that issue has come up—the data shown are from the test measurements on that power plant. What we have here are pounds per million BTU of SO_x and NO_x as compared to the EPA standards. The fuel cell data are actual measurements on that machine. I don't have the slide here, but if you would look at CO you would see the fuel cell produces only a fraction of the regulation value. In addition you would see a reduction in CO_2 and high efficiency. As a matter of fact you'll note a fellow who is standing next to the machine indicating it is a pretty quiet piece of equipment.

In summary the fuel cell is truly a clean, quiet machine and we're out there attempting to sell it.

That's the good news. The best summary I can make to you about our commercialization effort is that we have no SO_x, we have no NO_x, and we have no interest in the United States. Maybe more precisely, we have little SO_x, little NO_x, and little interest. And the reason for that is that the fuel cell powerplant is not the cheapest way that somebody can make electricity. There are ways to make electricity cheaper than with a fuel cell powerplant.

Unfortunately, the utilities tell us that in the regulatory climate that exists now, the thought of paying a premium price for a power plant that has no emissions, that is better than what is required by law, is just crazy and counter to the current regulatory climate. The regulatory process demands the lowest cost energy and just barely meets the emission standards. That's the criteria we deal with.

We view it differently, as you did Senator in your article this morning in the Hartford Courant; which I read with interest. It was very well thought through. What we've done is encourage our utilities to become net exporters—not just of power, but also of NO_x, SO_x, CO and particulates. What we do, then, after these pollutants cross the boundaries of the local utility, is create the problems that we're attempting to deal with today. It's difficult to see how we're going to handle all the consequences of this problem. So we don't pay the cost of all the dirty air in our utility bill; we pay for it in our tax bill. Make no mistake we pay for it.

There is no way that we, IFC, can take on the whole regulatory process. All I can tell you is that we need Federal help now. We're not going to get it from DOE because DOE, as was pointed out, is a

research and development-oriented organization. Their position is, "Hey, when we've done the research we'll toss the ball over the wall, and it's up to you after that." We're not going to get help from the Electric Power Research Institute (EPRI) either.

The only way you're going to bring the fuel cell into general use in this country is either through enacting much tougher environmental laws like—in effect, was done in the automobile industries—force the purchaser or the buyer of the equipment to take on the cost of emissions control because the law demands it. A second approach is for the Federal Government to take a leadership role and say, "Okay, it's too expensive to start, but we'll spend some Federal money and we'll put the fuel cell into Federal buildings. We'll start by introducing that equipment into Federal buildings and demonstrate the technology."

Or, you could provide some kind of financial help to the utilities so that they can effectively site the fuel cell within the current utility regulatory structure.

If we actually had some of these things happen so that we could get some production rolling, we might be able to get the costs down to where the premium for clean power isn't so high. With a new piece of equipment, we're competing with what has been around for 30 or 40 or 50 years.

There's a final option. That is to do nothing and wait until the Japanese come in and take the task on, because I'll tell you, they're after the business in a big way.

I guess my parting comment would be that it may be a better economic bargain for the country to pay a premium price for a power plant and have clean air than to pay the lowest price for the power plant and deal with the dirty air that it produces.

Senator LIEBERMAN. Thank you. I appreciate your ideas because they are right on target.

If I understand it, I believe what you are saying is that like so many businesses, you are at a stage now where the cost is not competitive——

Dr. LUECKEL. That's right.

Senator LIEBERMAN [continuing]. But the more units you get out in the field, the more you're going to understand about how to refine the product and how to ultimately produce it at a competitive price.

I like your idea about the Government being a purchaser of these.

Mr. GLENN. Senator, there is maybe a precedent with fuel cells particularly that doesn't exist with many other power generators that have come by that the utilities are now purchasing.

Much of the technology developed that the utilities are currently using started out as a military mission-oriented piece of hardware. Jet engines would be one example; the sophistication attained over the years became the turbines that we see today. Once that market was developed and the companies had cash flow, they could reinvest some of their profit into expanding the product line with improvements.

Fuel cells have not been able to identify a viable military mission. Therefore, to get a chance to commercialize with the military affordability—and they certainly have a need for power; it's a criti-

cal need, as a matter of fact, not only local but overseas—and then transpose that learning curve down to the commercial markets, it really is a lot harder a row to hoe as a precedent-setting generator goes.

Mr. CHERNOCK. Senator, I'd like to make some comments before this hearing is over and people walk away with a feeling that the costs for fuel cells are enormous.

Senator LIEBERMAN. Go ahead.

Mr. CHERNOCK. We represent an energy company, as I pointed out. Our interest is in producing energy on a competitively economic basis in a safe, reliable, environmentally sound approach. We look at fuel cells as basically that. We have set up not only internal hurdles at Combustion Engineering for dollars per installed kilowatt to excite our interest in fuel cell technology, but also as part of a DOE program there are hurdles associated with dollars per installed kilowatt.

I'd like to point out that on the basis of our preliminary studies done to date, we believe that even with a coal gasifier, using coal as the fuel, gasifying the coal, paying for the expense of a coal gasifier, that molten carbonate fuel cells will in fact be economically competitive. And when one goes out in future years and talks about a natural gas economy and does not require the coal gasifier at the head end of the process, natural gas fuel—molten carbonate fuel cells—will in fact be economical.

I think that in order for this to happen there needs to be a significant amount of DOE R&D and demonstration funding. Paper studies are great, but we have to go out and demonstrate this in actual operation, and that's where we would solicit your support.

There is another area that was mentioned by my friend from ERC, and that's the military interaction. We, together with Garrett Corporation and Argonne National Laboratory, are developing solid oxide fuel cells. The impetus for solid oxide fuel cells is basically the military; it's the aerospace. When you start looking at something you can put up there that has a power-to-weight ratio ten times better than any other type of fuel cell that you can put in the system, then the military becomes highly interested.

This whole area of solid oxide fuel cells has become embroiled in the political battles associated with SDI. As far as SDI is concerned, from a technological aspect, one hell of a lot of technology could and has come out of that program. I would hate to see solid oxide fuel cells, with the potential for a ten-to-one power-to-weight ratio, fall by the wayside as a result of that interaction.

I point out that the ultimate conclusion of the development of solid oxide fuel cells could very well put fuel cells in buses, trains, ships, possibly even automobiles. So that's another area that I think needs to be looked at.

Senator LIEBERMAN. What we could do to be of help is demonstration grant funding, perhaps getting the Government into purchasing some of the models.

What about stimulating the flow of investment capital to you? Is that a problem for you, is that not going to really increase the——

Dr. LUECKEL. No, that would help a lot. I think the problem is that this is high-risk investment capital. In spite of the fact that we at IFC don't share all the perspectives that I've heard here, it's

high-risk investment capital that's needed. Not many so-called "venture companies" will provide that. Loans don't really do it either, unless you can say, "I'm just going to walk away from the loan if things go bad." But if you're responsible about a loan, it really doesn't work.

The risk is that you will put the money in and nothing will change, and therefore the investment is lost, because the equipment that you need to build a fuel cell is very specific and can't be used for much else. It's specialized facilities and equipment.

Senator LIEBERMAN. The development of these products might be helped if we created some favorable tax treatment for investments?

Mr. GLENN. To slice the pie a little finer than my friend from IFC, there is capital——

Senator LIEBERMAN. You sound like Members of the Senate. We always refer to our "friends."

Mr. GLENN. I guess I'm in Washington too long.

There is investment capital, but it isn't local. The investment capital that we see around is coming from foreign sources.

Senator LIEBERMAN. And presumably they want a piece of the result.

Bill, you are licensing some of your early research and development to Japanese companies?

Dr. LUECKEL. That's right. That's exactly the problem. You've got to get the capital

Mr. GLENN. We're all in that position.

Dr. LUECKEL. We are all in that position. The U.S. companies won't accept that risk.

Senator LIEBERMAN. And you are doing it to remain economically viable as a company? In other words, you don't really choose to license it?

Dr. LUECKEL. Although I must tell you, I'm not sure you can go either into Europe or into Japan and say, "We're from the United States; we're over here to sell the fuel cell." If you don't tie in with those companies over there, you won't get in. They have the same reaction in reverse.

Senator LIEBERMAN. I understand. But isn't some of the reasoning why the licensing is going on, is to bring cash into Europe to fuel continued research?

Dr. LUECKEL. Yes.

Mr. CHERNOCK. Let me see if I could bring some of this back into the real world, if I could.

Commercialization—the earliest commercialization we can see on molten carbonate fuel cells is around the period of 1995 to 1997. The earliest commercialization we can see for expansion of that into a coal gas-fueled molten carbonate fuel cell is on the order of the year 2000. The earliest we can see commercialization of solid oxide fuel cells is around the turn of the century, or immediately after the turn of the century.

These are technologies that this Nation must develop. To sit here today and look at investments in something that is in a developmental stage with good potential for economic payoff if developed adequately, good environmentally benign characteristics, to sit here in the year 1989 and say, "Hey, let's get a lot of investment into something that will hit the market in 1997 or the year 2000," I

think is asking an awful lot. I think that this is something that the U.S. Government via DOE needs to pursue, needs to pursue heavily, and needs to recognize the potential for it and to fund it accordingly.

At the appropriate time, U.S. industry will step forward and invest.

Senator LIEBERMAN. Okay.

I've got to wind this up. Did somebody over there want to add something? I think one of the utility people wanted to talk about the problem of cost-competitiveness of these new products. Peter.

Mr. BOUCHER. The gentleman that suggested that there is a regulatory barrier to the introduction of even conventionally-available fuel cells is certainly correct.

When we set rates and look at the capital investment programs of our utilities, we are looking at the least cost means of meeting their customers' requirements. If there is a more environmentally benign technology which has much more cost, we're not really in a position to tell them to go ahead and do it.

I think what you really need to do is to set higher standards and make them apply to everyone, so at that point you're going to have the environmentally benign technology becoming cost-effective with other less environmentally benign technologies.

Mr. CAGNETTA. Let me add to that, Senator. With PURPA regulation and the introduction of third parties, it makes it even more uncertain for large utilities in that you have a situation where you have small developers and they're not about to take a risk with development of a new technology. In the past you had large utilities that had the financial capability to take that risk, but at this point, with the uncertainty of them providing that generation for the 21st century because of third party development, it creates another barrier for utilities to think about developing new sources.

Senator LIEBERMAN. Understood.

I really want to thank all of you who were on the panels and all the State legislators—State Representative Lee Samowitz has joined us now—all the legislators who came by, and everyone else who took the time to be here today. I found it to be a very valuable morning. I've come away feeling that we have a global warming problem, and that some of the answers to the problem will not only help us with that but will help us with an obvious long-term energy problem, and with a sense that we are doing something here in Connecticut in conservation and efficiency and in research and development of some products that can help, not only here but throughout the country and throughout the world. I feel good about taking this record back with me to Washington and sharing it with my colleagues as we consider the various global warming bills that are before the Environment Committee, and hopefully work toward reporting some of them out during this session.

Thank you very much. This concludes the hearing.

[Whereupon, at 12:05 p.m., the subcommittee was adjourned, to reconvene at the call of the Chair.]

[Statements submitted for the record follow:]

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BEFORE THE

SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION
COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
U.S. SENATE

AUGUST 10, 1989
HARTFORD, CONNECTICUT

Senator Lieberman, it is a pleasure to appear before this Subcommittee today to testify on the issue of global warming and its implications for energy policy.

Introduction

The global warming issue has been studied for many years by scientists interested in understanding how our planet functions.

The earth has a number of characteristics which make life possible. One of the systems which makes life possible is the greenhouse effect. Greenhouse gases trap energy in the atmosphere that would otherwise escape into space. If these molecules in the atmosphere did not perform that role, the earth would, on average, be 63 degrees Fahrenheit colder.

This atmospheric phenomenon exists on other planets. Venus is extremely hot because its atmosphere is largely a thick blanket of carbon dioxide, the most important greenhouse gas. Mars is far colder than earth because its atmosphere does not have the greenhouse characteristics of the earth.

The importance of greenhouse gas concentrations in controlling the earth's climate can also be understood by examining previous atmospheric concentrations of greenhouse gases, and the relationship of those concentrations to the earth's then prevailing climate.

Scientists have examined ice cores in the Antarctic and have been able to reconstruct past climates and concentrations of greenhouse gases through the past 160,000 years (see Figure 1). That analysis documents that the concentration of greenhouse gases has changed substantially over the past 160,000 years. As concentrations have changed so has the climate of the earth. The earth has gone in and out of ice ages over this period. As the earth has moved in and out of such periods, the greenhouse gas concentration of the atmosphere has changed. Warmer climates have had higher concentrations of greenhouse gases. Ice ages have had lower concentrations.

Thus the examination of the atmospheres of other planets and the examination of past climates of the earth support the hypothesis that increasing the greenhouse gas concentration of the earth's atmosphere will warm the planet. At a recent scientific workshop on the greenhouse effect in Amherst, Massachusetts a statement of the participants concluded that:

> *"It is certain that increasing concentrations of carbon dioxide, methane, chlorofluorocarbons and other trace gases will enhance the greenhouse effect."* [1]

Is This a Crisis Today?

The global warming problem is with us now because the concentration of greenhouse gases is rising in the atmosphere at an extremely rapid pace. Since the start of the industrial revolution atmospheric carbon dioxide levels have risen by 25 percent -- a change in concentration from 280 to 350 parts per million (ppm) (see Table 1, Figure 2).

During the shift from glacial to interglacial times that occurred about 18,000 years ago the carbon dioxide concentration in the atmosphere rose from about 200 to 280 ppm -- a 40 percent increase. During that change the average global temperature increased by about 8 degrees F or 4 degrees C (see Figure 3).

Human activities since 1860 have already raised CO_2 concentrations by 70 ppm. This suggests that emissions over the past hundred years or so have already committed the earth to a significant warming (as much as 2 degrees C). Scientists believe that due to the heat absorbing character of the oceans there is a lag of a few decades between the emission of greenhouse gases and global temperature increases. It is important to remember that during the past two million years, while the earth has been in a glacial interglacial cycle, the global temperature has probably not been more than 2 degrees C warmer than today.

If scientific estimates are correct, the earth's temperatures based on emissions of the past 100 years could rise to their highest levels in two million years. Future emissions could take the earth far beyond into temperature ranges not experienced on the planet for tens of millions of years.

For policy makers the issue has arrived, because past emissions have already set the stage for a significant alteration of the earth's climate. Future emissions should increase the probability and the risk of climate change.

The Impacts of Climate Change

In a recent letter to Science, Wallace Broecker of the Lamont-Doherty Geological Observatory argued that the historic records of the Antarctic ice core and of marine sediments,

> *"...scream to us that the earth's climate is highly sensitive to nudges....The issue is that by adding infrared absorbing gases to the atmosphere, we are effectively playing Russian roulette with our climate."* [2]

Rising concentrations of greenhouses gases will warm the earth. Within forty years the earth may be committed to a warming of between 1.5 to 4.5 degrees C. The average warming of the earth is only one of many possible impacts. Sea levels will rise -- perhaps as much as three feet or more in the next century. Rainfall patterns will shift. Agricultural zones will move and agricultural productivity will be threatened.

Natural ecosystems will come under greater stress and many species will be unable to migrate to new and appropriate habitats. Seasons will be a different length and character. Extreme events may increase as climate becomes a phenomenon that is characterized not by events within a fairly predictable range, but by increasingly extreme events which have no precedent in recent history.

We are entering what might be called a super interglacial period, a climate regime not witnessed on the planet possibly for tens of millions of years. We will enter that period at an unprecedented rate of change. Consequently, global surprises may be as big a part of the future as climate alterations that we can predict.

Five Greenhouse Gases

There are five major greenhouse gases. Carbon dioxide is the most important greenhouse gas -- contributing about one half of the increase in global warming per decade. The major source of the carbon dioxide build-up in the atmosphere is the burning of fossil fuels. The second significant source is the destruction of tropical forests which produce carbon dioxide through burning or decomposition.

Chlorofluorocarbons, which are destroying the ozone layer, are a greenhouse gas and represent about 20 percent of the problem. CFCs are used in a wide variety of products and manufacturing processes, but are now the subject of an international protocol[3] which requires that their consumption in industrialized countries be cut in half over the next ten years. A revision of that international protocol is likely, resulting in the phase-out of these chemicals by the year 2000.

Methane is the third major greenhouse gas and comes from a wide variety of sources including the production of fossil fuels, agricultural sources, natural ecosystems, and from chemical processes in the atmosphere involving conventional air pollutants.

Ozone in the troposphere is a greenhouse gas. We have "good ozone" in the stratosphere which protects us from ultraviolet radiation and "bad ozone" at ground level which is a major air pollutant. Ozone in the troposphere (the portion of the atmosphere below the stratosphere) can be thought of as a third type of ozone -- perhaps warm ozone.

The fifth significant greenhouse gas is nitrous oxide for which the largest source is probably nitrogen-based fertilizers.

Indirect Greenhouse Gases

It is important to note that through the processes of atmospheric chemistry other pollutants contribute to the formation of greenhouse gases. Carbon monoxide and nitrogen oxides both regulated by the Clean Air Act, indirectly contribute to the formation of methane and tropospheric ozone. However the Clean Air Act focuses on a regional or local rationales for controlling these pollutants. It may now be important for Congress and the EPA to consider the control of these pollutants on a national basis because of their contribution to the greenhouse effect.

The United States Contribution

The United States is the largest producer of carbon dioxide in the world. We have been the number one emitter for decades (see Figure 4). With about five percent of the world's population we emit about 23 percent of the world's carbon dioxide. Our share of the global total has declined in recent years due to the economic and population growth of other nations but global CO_2 emissions are at an all time high.

However, in 1987 the year for which the most recent statistics are available, the United States share of the total increased. The U.S. CO_2 emissions rose by almost two percent while the global total increased by 1.5 percent. In 1988, the United States CO_2 emission increases may have exceeded three percent.

Because of the size of its emissions, the United States role in this issue is central. Many other governments will be unlikely to control carbon dioxide emissions unless and until the United States demonstrates a seriousness of its own strategy. Some have tried to argue that because our share of the world total has been declining, our leadership is less important. In light of the 1987 data and the historical data (that we have been the world's leading producer for decades), the United States is likely to come under increasing pressure to put its house in order on the global warming problem. We run the risk of becoming isolated internationally unless we aggressively pursue measures to cut our contribution to the problem and our share of the world total.

Some hope may be placed in a recent announcement from the U.S. DOE, when Secretary of Energy James Watkins announced a timetable to develop a National Energy Strategy.[4] Unfortunately, options will not be ready for the President before the end of 1990. The strength of Secretary Watkins' proposal was his commitment to fully integrate environmental issues into the energy planning process.

There are two weaknesses in DOE proposal. First, it is not clear that an outcome of energy policy process will be actions on carbon dioxide emissions. Second, the timetable imposed on the process may not move at a rate sufficient for the international deliberations now underway.

The G-7 Summit

The most important document to date on the policy responses to global warming is the communique of the G-7 summit agreed to by seven heads of state. There are at least three important statements made at the G-7 which should now constrain United States policy and offer some hope for early movement on U.S. CO_2 emissions. It will be easy to test the seriousness of these statements, because the next economic summit is in the United States and the question of whether the objectives of the Paris Summit have been met can certainly be determined.

The first of the three statements is from paragraph 33 of the Economic Declaration. It states:

> *"...decisive action is urgently needed to understand and protect the earth's ecological balance."*

That statement reflects the urgency now attached to declining global environmental conditions. In fact it was reiterated by President Bush at his news conference following the summit.

What those decisive action are and when they will be taken have not been defined.

The second statement is from paragraph 40 where the heads of state

> *"...strongly advocate common efforts to limit emissions of carbon dioxide and other greenhouse gases."*

This may be the most important statement in the environmental portion of the communique. How will the United States respond to paragraph 40 in which the President has agreed to limit greenhouse gases? This represents the first important statement on a CO_2 policy by the Administration. The Congress should now ask the Administration for specific measures which will implement paragraph 40.

The Third statement of importance is in paragraph 45 in which the leaders proclaimed that:

"...a framework or umbrella convention on climate change ...is urgently required."

This presumably means that for the first time the Administration now supports the conclusion of a framework convention. Unfortunately no target date has been set to conclude such a convention, despite the fact that the heads of state believe that it is urgent. Many observers think that such a convention could be negotiated and signed within a year from the point at which such a draft convention is tabled.

The communique also expresses strong support for improvements in energy efficiency, efforts to halt the destructions of tropical forests, plans to phase out CFCs, and strengthening the efforts of the United Nations to protect the environment.

In October dozens of nations will gather for a meeting of the Response Strategies Working Group of the Intergovernmental Panel on Climate Change, a multilateral institution established last year under the auspices of the United Nations, to frame the climate change issue. The United States chairs this effort which is designed to come up with policy responses to the greenhouse problem. This meeting will give an early indication of the impact the G-7 Communique.

The Roles of the States

Although the global warming problem has been largely conceived in global terms, much of the energy policy response and emissions controls will be carried out at the state and even the local level. Many of the impacts of global warming will also have to be managed by state and local government, so it is not too early to develop strong and well organized state programs and initiatives. State efforts may set examples for the federal government on how to control greenhouse gases and how to cope with potential changes in climate.

Three potential efforts might be useful for Connecticut.

- First, the state should consider setting up a task force to explore the possibility of limiting greenhouse gas emissions. Major policy efforts would have to be aimed at the electric utility and transportation sectors (see Figure 5). There are a variety of energy policy options that could be considered by such a task force including a long list released last week in a report of the National Governors Association.[5] Targets for greenhouse gas emission reductions could be established and implemented over coming years. New York State is considering the establishment of a target of reducing CO_2 emissions by 20 percent by the year 2000.

- Second, the State could consider setting up a commission to look at the impact of global warming and how state policy might begin to deal with gradually rising sea levels, a major shift in the types of forests that survive in the state, the possible impacts on water supply, changes in energy demand, and effects on public health.

- Finally, the state could make an effort to see the opportunities which the greenhouse effect will create. The world community may soon be demanding an entire new range of energy technologies to deal with this problem. Will American companies be positioned to be leaders in the rapid introduction and marketing of such products? It is possible that a far reaching and rapid transition of our energy economy may be required. That possibility and that opportunity should be taken seriously by American business.

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FIGURE 1.

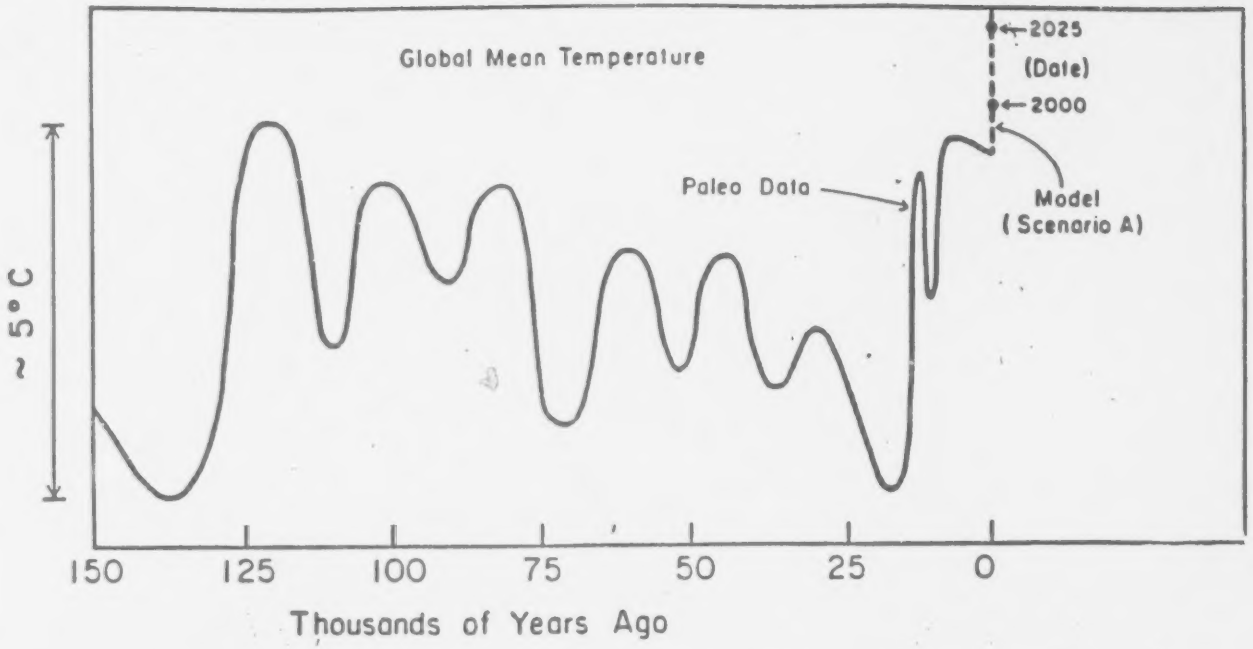


Fig. 2. Smoothed global mean temperature trend during the past 150,000 years and the simulated future temperature trend for trace gas emission scenario A.

TABLE 1.

Key Greenhouse Gases

- **Present concentrations in air**
- **Rates of increase**
- **Pre-industrial era concentrations**

ppm = parts per million
ppb = parts per billion
ppt = parts per trillion

Gas	CONCENTRATION IN AIR Pre-industrial	1986	Present Rate Of Increase (Per Year)
Carbon dioxide (CO_2)	275 ppm	346 ppm	1.4 ppm (0.4 percent)
Methane (CH_4)	0.75 ppm	1.65 ppm	17 ppb (1.0 percent)
Fluorocarbon-12, (CCl_2F_2)	Zero	400 ppt	19 ppb (5.0 percent)
Fluorocarbon-11, (CCl_3F)	Zero	230 ppt	11 ppt (5.0 percent)
Nitrous Oxide (N_2O)	280 ppb	305 ppb	0.6 ppb (0.2 percent)
Ozone, Tropospheric (O_3)	15 ppb?	35 ppb	0.3 ppb? (1.0 percent) Northern Hemisphere Only
Other Fluorocarbons	Zero		(5 to 15 percent)

FIGURE 2.

Historical Variation in Carbon Dioxide Concentration

Source: G.J.MacDonald, The MITRE Corporation, 1987.

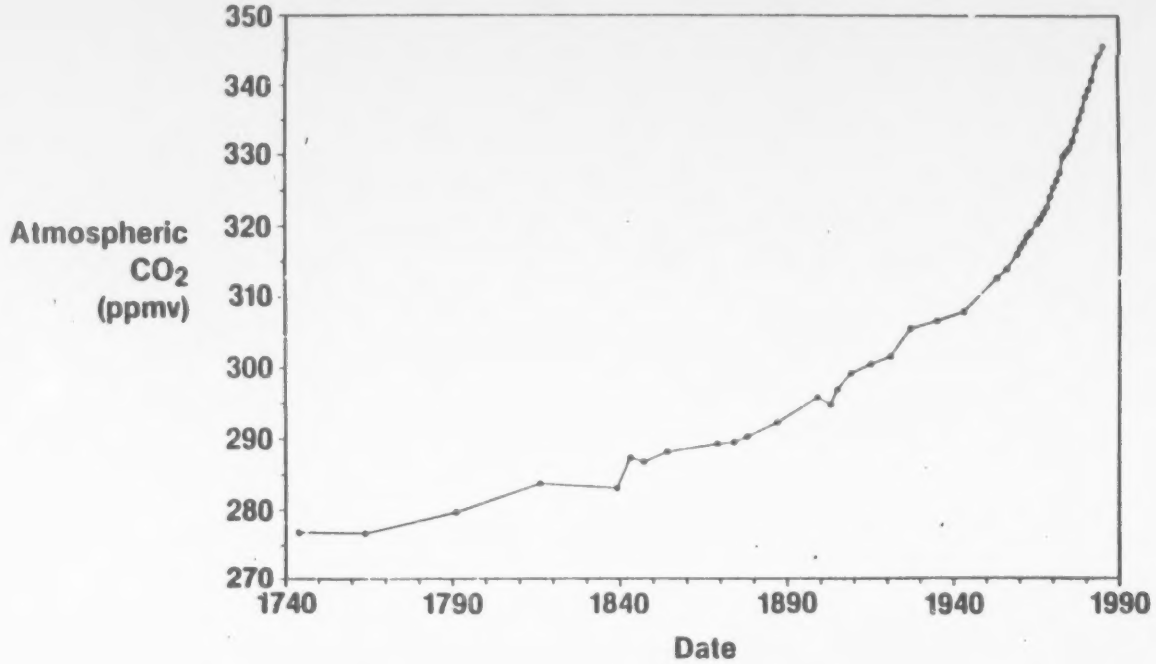
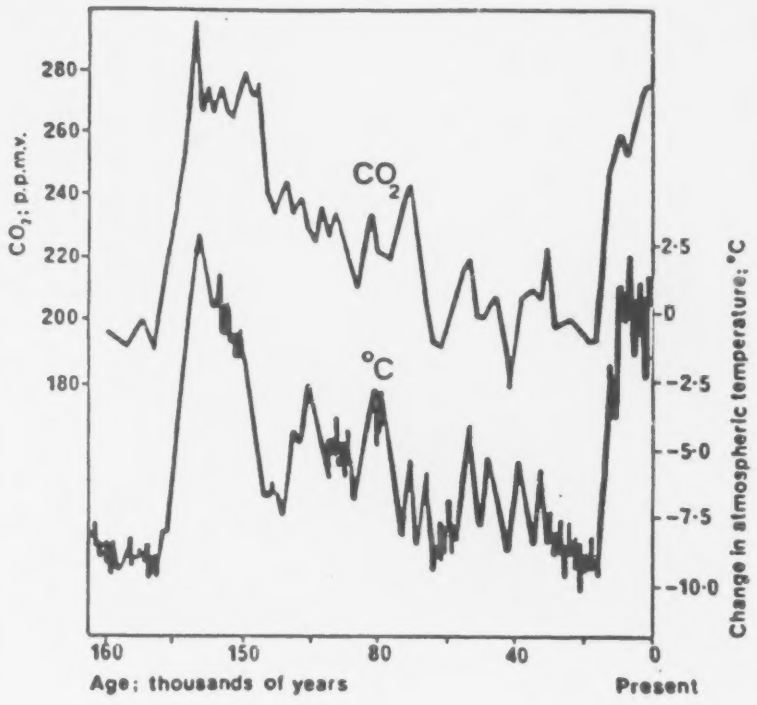


FIGURE 3.

CO_2 Concentrations and Atmospheric Temperature Changes at Different Ages in the Vostok Ice Core

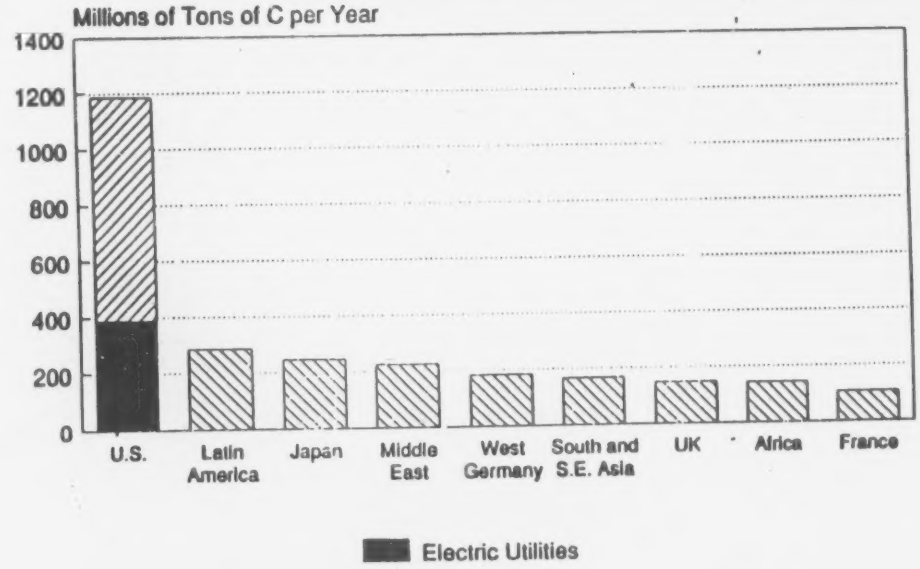


Source: Barnola, J.M. et al (1987); Vostok Ice Core Provides 160,000 Years Record of Atmospheric CO_2; Nature 329 pp408-414.

WORLD RESOURCES INSTITUTE

FIGURE 4.

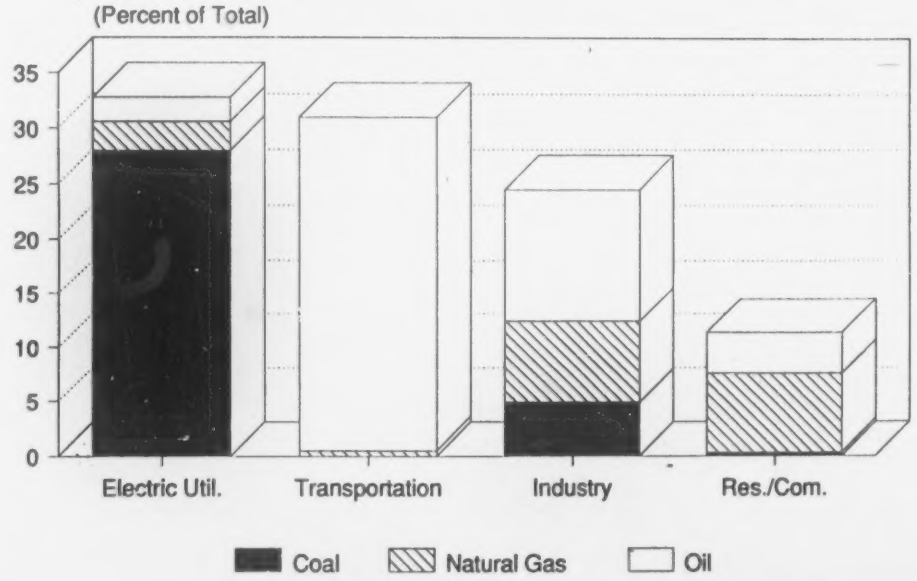
U.S. CO2 EMISSIONS COMPARED WITH THOSE OF SOME OTHER REGIONS (1985)



Source: World Resources Report 1988-1989

FIGURE 5.

CARBON DIOXIDE EMISSIONS IN THE U.S. BY SECTOR AND FUELS (1988)



THE SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION

OF

THE U.S. SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE

THURSDAY, AUGUST 10, 1989
HARTFORD, CONNECTICUT

JOHN P. CAGNETTA
SENIOR VICE PRESIDENT
CORPORATE PLANNING AND REGULATORY RELATIONS
NORTHEAST UTILITIES

I want to express my appreciation to the Subcommittee on Environmental Protection for inviting me to testify on Northeast Utilities' (NU) resource planning over the last two decades as it relates to the global warming concern. The supply options we have selected during the last two decades have contributed significantly to reducing environmental impacts from NU operations and specifically mitigating the global warming problem. Although I might hasten to say these actions had their rationale in optimal economic costs to our ratepayers, and in enhancing strategic resiliency to oil shutoffs and were not driven by global warming concerns, I will also touch on the actions that electric utilities and state and federal energy officials could take that will minimize the long-term impact on our atmosphere of waste products from the generation of electric energy.

In its resource planning over the last two decades, NU has demonstrated it is sensitive to environmental effects. Our actions to mitigate such effects in the generation of electricity have been taken in recognition that we all are stewards of this earth, and that we must pass on to the next generation the gift of our ancestors--an environment that is healthful and safe.

NU has been recognized for its efforts. For example, the Company received the United States Department of the Interior "Take Pride in America" award for environmental and recreational excellence. We were cited by the Connecticut River Salmon Association for helping restore salmon to the Connecticut River. And NU received the Connecticut Department of Environmental Protection's award for meritorious stewardship of America's natural resources for protecting bald eagle habitats.

In 1967, NU's energy mix was nearly 95 percent fossil-fueled. Over the next two decades, we at NU developed extensive nuclear technology, expanded our hydro capability, reduced our use of high-sulfur oil, introduced natural gas as a dual fuel for fossil plants, and made major capital investments in pollution control equipment, fish and wildlife management, and recreational development in the vicinity of our power plants. Most recently we have developed extensive demand management programs that reduce our marginal use of fossil fuels, delay the need for new generating facilities and also help control the cost of electricity for our customers.

Clearly, our customers and shareholders do and will continue to incur significant costs to ameliorate past and future environmental impacts, and to enhance the natural environment in the vicinity of our power facilities. I estimate that as much as 15 to 20 percent of our operating

costs are attributable to more demanding environmental legislation and regulation, which we consider wholly appropriate in light of the need to protect and preserve the environment.

Let me now speak chronologically to NU actions over the last 20 years as they relate to the environment. The earlier actions focused on supply options, and later actions reached out to demand side options. The first supply option that reduced our fossil dependency was the introduction of nuclear technology. The initial motive for embracing nuclear technology was clearly twofold: the favorable economics of nuclear capability compared to the fossil technology of the 1960s, and the need to reduce the strategic national and economic risk associated with dependence on foreign oil. But in retrospect, we now know that nuclear technology has had other benefits as well.

Our nuclear commitments have substantially helped in improving air quality and have reduced our contribution to global warming. Our nearly total fossil dependency of 1967 was reduced by 1988 to 27 percent, with a balance of 68 percent nuclear, 3 percent hydro and 2 percent cogeneration and small power production. As NU and others in New England were expanding their nuclear capability, other parts of the nation were expanding their coal capability -- and in the earlier stages of this coal expansion many plants were added that do not have flue gas desulfurization systems (scrubbers). Where scrubbers have been applied over the last decade, they remove up to 90 percent of sulfur dioxide (a contributing cause of acid rain) and 99 percent of fly ash. But scrubbers don't remove gases that contribute to the "greenhouse effect" such as nitrous oxides (which also cause acid rain) and carbon dioxide.

On the other hand, New England's eight operating nuclear power units generate more than one-quarter of New England's electricity requirements with no "greenhouse effect" gases and no acid rain emissions. If the region's nuclear plants had been built as comparably sized, scrubber-equipped coal-burning plants, they would annually produce 92,000 tons of sulfur dioxide; 99,000 tons of nitrous oxides; 5,000 tons of particulates; and 36 million tons of carbon dioxide.

But neither NU nor any other electric utility will consider nuclear in the next decade unless a number of significant social and political barriers are addressed by national energy policy and programs. However, it is important that we continue to operate all the presently constructed nuclear plants, for they are critical to meet today's load and they will continue to reduce dependency on fossil fuels, with the

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above-mentioned benefits. We are prepared to work with Subcommittee members in maintaining our nation's present nuclear capability and possibly in considering a nuclear option for the 21st century.

Over the last 15 years (since the first Arab oil embargo), NU expanded its run of river hydro capability, which also has contributed to our reduction in the use of fossil fuels. During that time, NU added and restored more than 22 megawatts to our run-of-river hydro, which now amounts to a total capability of 210 MW. NU also has a pump storage hydro station in Massachusetts, with a capability of 1,100 MW, and which daily displaces the use of low-efficiency combustion fossil fuels at times of system peak hours. This hydro station's storage reservoir is filled by pumps powered with electricity that is generated by nuclear and other high-efficiency plants, and hence has the effect of reducing our system fossil dependency. Some hydro capability has been developed by third parties under PURPA, and the power output is being purchased by NU's operating companies. Finally, a fourth source of hydro capability has been achieved by power purchases from Hydro Quebec, which has significant hydro capability.

Hydroelectric resources in NU's service territory contributed over three percent of NU's system energy needs in 1988. We expect further development of hydro in the NU service territory to be very limited given the intensive economic development that came about under PURPA and the environmental constraints related to recreational use of rivers and the state and federal fish restoration programs.

Canadian sources of undeveloped hydro capability far exceed any New England capability. However, there are numerous constraints as to access to new corridors for additional transmission lines, and there are associated environmental impact concerns. We expect there may be some further expansion of our ties to Canada, but these additional ties will satisfy only a portion of our regional electric needs over the next decade.

A final supply option that may be deployed in the next decade is an advanced solar technology, but again I expect it will be limited in application given the present economic disadvantage and the pace of development of this technology.

My remarks thus far have focused primarily on supply options that reduce our dependency on fossil fuels, but I noted in my introduction one other major source of reduction in the use of fossil fuels -- and that is more efficient use of electric energy.

At NU, resource planning is accomplished through an Integrated Demand and Supply Planning Process (IDSP). In IDSP, we seek to identify the best combination of new resources. One key area on which the Company focused its resource planning activities in the 1980s was the continued expansion of its Conservation and Load Management (C&LM) programs. With encouragement and direction from our state regulators, the Company has worked closely with interested parties through a "collaborative planning process" in both Connecticut and Massachusetts.

New England utilities have accomplished significant actions in response to the New England Governors' recommendation to accelerate the planning and implementation of cost-effective conservation and load management. In Connecticut, NU has instituted a collaborative effort with all advocates of conservation, including the State Energy Office, the Office of Consumer Counsel, the State Prosecutorial Division, and the Conservation Law Foundation, to identify all the conservation and load management opportunities. Program designs have been agreed to and Connecticut Light and Power, the Connecticut operating company of NU, is now in the process of implementing these expanded programs.

In Massachusetts, NU acted as a coordinator in a similar collaborative effort that involved five Massachusetts utilities, including NU's Western Massachusetts Electric Company subsidiary (WMECO), the Energy Office, the Attorney General's office, Massachusetts Public Interest Research Group (Mass PIRG), and the Conservation Law Foundation. This Massachusetts collaborative effort to develop expanded conservation programs has also been successful. The Massachusetts utilities are expecting to submit their detailed plans to the Massachusetts Department of Public Utilities in the upcoming months, with implementation already beginning for some programs.

NU has crafted conservation programs to benefit all classes of customers -- residential, commercial and industrial. A summary of the programs is given in Exhibit 1. We've helped provide energy audits and conservation services to more than a quarter million homes since 1980. And we're helping architects and contractors create buildings that save the maximum energy, from solar home designs to energy planning services for business and industry.

Overall, NU's C&LM programs already at work have accomplished a peak load reduction of 225 MW off our 1988 summer peak and 215 MW off our 1988 winter peak. Our expectation is that by 1998 the C&LM programs will be able to reduce our summer peak load by some 600 MW and our winter peak load by about 500 MW (enough to offset the need for an additional power plant the size of Connecticut Yankee

nuclear plant, the fourth-largest generating unit in the NU system). This is in comparison to our current peak load of about 4800 MW (summer and winter peak loads for NU have been about the same and are expected to be close to each other in the future). It is our goal to manage our system load so that the power supply requirement will be about the same for either the summer or winter peak load.

There have been similar efforts in other New England states. The overall New England effort to date has resulted in an identification and implementation of customer conservation actions that are expected to reduce the NEPOOL summer peak this year by 800 MW, and expected to reduce the 1995 summer peak of 24,000 MW by 1900 MW.

There are opportunities for regulatory and legislative actions to institutionalize the conservation gains for the long term. NU and other utilities in New England have been working with the Energy Offices and regulatory agencies in our states to upgrade energy appliance standards and new building standards. To the extent that these or national standards are upgraded, the burden to ratepayers of continuing to finance conservation investments is significantly reduced. We are hopeful that the utility initiatives over the next few years will provide the foundation for legislative and regulatory actions to upgrade the standards or take other initiatives that will create the incentives to allow the market place to make customers select the more efficient end-use technologies.

NU's expertise in conservation program development has gained attention even from overseas. This year top energy officials from Sweden chose NU as the only major U.S. electric utility for modeling crucial aspects of a conservation program in their country. From Thailand came energy experts seeking to learn through NU's conservation programs ways of coping with an incredible annual electric demand growth of 12 percent. And from Russia we received energy officials seeking advice on solving an array of demand-side problems.

Here at home we have our own concerns, too. In order to wage as effective a war against global warming as possible, Congress should put registered holding companies like NU on the same footing as unregulated companies who are using their advantage in leveraging funds to move into the energy conservation services area. The Public Utility Holding Company Act of 1935 needs to be amended to allow holding companies like NU to offer conservation services in geographic areas beyond their present service territories.

We at NU believe that by working together, we can all be assured of maintaining a safe, clean, reliable and efficient source of electricity for future generations.

# # # #

C&LM PROGRAM SUMMARY

	TARGET MARKETS	INCENTIVE	PROGRAM FEATURES
CONN SAVE/Comfort Corps	All residential customers in 1-4 unit dwellings	Subsidized audits combined with some fully subsidized and full cost measure installation	Home energy audits and weatherization services. CONN SAVE participants get $37 free weatherization materials installed
New Construction (Energy Value Home)	New residential elec. heated homes	Full incremental cost on thermal shell improvements	Proposed upgrading of thermal envelope standards including insulation and high performance windows, high efficiency appliances
Max-A-Miser	Existing electrically heated homes	Proposed full incremental cost with cost sharing for ceiling insulation and storm window installation	Blower door assisted weatherization and domestic hot water conservation services as well as cost sharing for ceiling insulation and storm windows
Pool Pump Pilot Program	Residential customers with in-ground pools	Incentive payment to customer	Provide free installation of radio control for pool pump motors
Energy Value Water Heating	Residential customers with electric water heaters	Free controler installation and full subsidy for measures in fraction of participants	Provide free installation of hot water conservation measures (pending regulatory approval)
Low Interest Loans (ECLP)	All residential customers in 1-4 unit dwellings	As low as zero-interest loans	State administered loans granted to finance energy conservation measure installation
Public Housing-electric	Existing electrically heated homes	Buy down to zero interest for loans made to PHA's to install energy-efficient measures	Weatherization, domestic hot water conservation services, efficient appliances
Residential Appliance Labeling	Residential customers purchasing replacement appliances	No direct incentive; advertising and information	Encourage customers to purchase appliances ranked top 15% of energy efficiency through appliance labeling

Exhibit 1

C&LM PROGRAM SUMMARY

	TARGET MARKETS	INCENTIVE	PROGRAM FEATURES
Domestic Water Heating Program	Residential customers with electric water heaters who are not participating in any other CL&P program which provides water heater wraps	Full incremental cost for hot water measures	Provides free installation of hot water measures
WRAP Program	Existing low-income residential	Full incremental cost of measures	Provides thermal shell, heating system and fluorescent lighting services to non-electric heat customers. Will provide $150 to 600 for these services for electric heat customers in conjunction with publicly-funded weatherization
Energy Care	Low- and fixed-income customers	Free workshops, special services	Free workshops on energy conservation, safety and budget management. NU-HELP pilot offers special payment arrangements and weatherization
Energy Cons. Construction	New non-residential buildings	Up to full incremental costs of measures	Incentives for design and installation of measures that save electric energy
EnergyCHECK Conservation Services	Small to medium commercial and industrial customers	Subsidized audit combined with some measures installed at no cost	Energy audits, installation of up to $100 of energy efficient measures
Energy Action Program (Commercial)	Large commercial buildings	Buy down to a 3-year payback with a 50% cap	Contractor/arranger assistance in identifying and financing energy conservation measures
Energy Action Program (Commercial)	Industrial customers	Buy down to a 3-year payback with a 50% cap	Contractor/arranger assistance in identifying and financing energy conservation measures
Customer Initiated	Large commerical and industrial customers	Payment for energy savings at specified level	Unsolicited proposals from industries and large commercial customers to achieve energy conservation

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TESTIMONY OF

CONSERVATION LAW FOUNDATION OF NEW ENGLAND, INC.

BEFORE THE

SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE

ENVIRONMENTAL PROTECTION SUBCOMMITTEE

AUGUST 10, 1989

CLF Conservation Law Foundation of New England, Inc.

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Mr. Chairman, Members of the Subcommittee, and Staff:

My name is Armond M. Cohen, and I am a Senior Attorney with the Conservation Law Foundation of New England, Inc. (CLF). CLF is a non-profit environmental law organization representing several thousand members in the six New England states on a variety of issues of environmental concern, including global climate change and energy use. We appreciate the opportunity to present the subcommittee with some good news, which is rare in connection with such a frightening topic as global warming.

My message is simple: there is a readily available means to mitigate substantially the introduction of climate-altering carbon dioxide into the atmosphere. This same mechanism will also reduce acid rain and urban air quality problems, and reduce society's energy bill. This device is technologically feasible, it will result in no inconvenience or lifestyle change to society, and it will actually increase our standard of living. And it draws one of America's central strengths: technological innovation and precise engineering. As you will see in a moment, this seemingly miraculous mechanism is not really so miraculous after all, since it is taking place even as we speak, though not nearly enough. What I am referring to is large scale investment in energy efficiency.

Notice that I do not refer to "energy conservation." I avoid that term deliberately, with its connotations of sacrifice and curtailed production. When I speak of energy efficiency, I am referring to the sustained application of engineering and capital to reducing the amount of fuel wasted in America's buildings, industrial processes, and transportation. Energy efficiency means homes that sip rather than guzzle energy to provide the same amount of warmth; it means high-efficiency office lighting that produces better light at one-quarter of traditional power requirements; and it means motors on the shop floor that are tuned with computer controls so that they don't overpower the process they drive. In short, energy efficiency means doing more with less, not doing without.

I will concentrate today on the potential for energy efficiency in one part of the energy sector -- electricity -- as it is the one with which I am most familiar, and the one where the most rapid changes are occurring, especially here in New England. But the same techniques and policies I will discuss can

be extended to other fuels and to the transportation sector.

The Energy Efficiency/Global Warming Link

Why focus on electrical efficiency as a key to the global warming riddle? Numbers, to begin with. As Exhibit 1 shows, the electric utility sector contributes over a third of the man-made CO2 emissions in the United States, which emissions in turn account for about half the global warming problem (see Exhibit 2). As Exhibits 3 and 4 show, increasing electrical efficiency will also pay handsome environmental dividends in other areas, since power plants account for nearly two-thirds of the nation's sulfur dioxide emissions and about a third of its nitrogen oxides, a major culprit in ozone smog.

A single concrete example will serve to illustrate the enormous impact that increasing electrical efficiency could have in mitigating global warming. And where better to start than with Mr. Edison's invention: the lightbulb? Figures from the Lawrence Berkeley Laboratory (the nation's leading energy efficiency laboratory) illustrated in Exhibits 5 and 6 indicate that installing just one high-efficiency compact fluorescent light bulb will reduce the need for an electric utility to burn over a quarter-ton of coal, nearly a barrel of refined oil, and will thus save the atmosphere from up to 380 pounds of additional emitted carbon. And that's just a small example. The same analysis shows that installing a single high-frequency electronic ballast into a four-lamp lighting fixture (of which there can be many hundreds in a single office) can approximately double those savings.

As will be discussed below, these bulbs and ballasts (and thousands of other high-efficiency innovations just like them) not only reduce environmental stress; they also save society (that is electric utilities and their ratepayers) a huge amount in direct energy bills. Installing the bulbs I referred to, for example, will cost about 2 cents per kilowatt hour of energy saved, as compared with 6 or 7 cents per kilowatt hour to produce that energy from a new power plant. Energy efficiency is not only an environmental win/win; it's an economic win/win, too.

At least three questions immediately leap to mind when one ponders these huge potential benefits from increased energy efficiency:

- o how much is out there to be had?
- o why isn't it all being gotten today?
- o how do we accelerate it?

Technical Potential for Electrical Efficiency

Surprisingly, there is little dispute among engineers and even utilities and environmentalists about how much we can technically increase electrical efficiency. All agree: the potential gains are huge.

This point is illustrated in Exhibits 7-10, which summarize the findings of a report released two years ago by CLF and several state agencies and environmental organizations, based on data from the Lawrence Berkeley Laboratory and other research institutions. Entitled Power to Spare: A Plan for Increasing New England's Competitiveness Through Energy Efficiency, the report asked the question, How much could we decrease electric demand in New England, while preserving the same level of economic growth and consumer comfort, if we could saturate homes, businesses and factories with readily available high-efficiency electric equipment and building shell measures that saved energy at less than the cost of producing it? The answer was astonishing, as Exhibit 9 shows: New England could reduce future consumption by about 35%, thus keeping electric demand growth level over the next two decades. If savings from new technologies expected to come on the market were counted (and this is an area characterized by rapidly accelerating innovation), the report showed, we could decrease our electric demand in absolute terms by nearly a third over the same period -- again assuming robust economic and demographic growth in the region.

These technical projections are by no means at the edge of the mainstream. No utility has challenged our major findings, and, indeed, recently these results were cited by the chief executive officer of Connecticut's largest utility, Connecticut Light & Power, as evidence of how far we need to travel.

How rough is the journey going to be?

Barriers to Electrical Efficiency

Increasing electrical efficiency is a lot like maintaining an adequate national defense: it's complicated, it's expensive, and the benefits aren't immediately visible to those who must pay. Put another way, as with maintaining our armed forces, the "free market", left to its own devices, will just not take care of this problem -- in the foreseeable future, anyway.

The first major "market imperfection" that blocks energy efficiency is simple lack of information. This is an area of explosively rapid technical and commercial development. The compact fluorescent lightbulbs and electronic ballasts referred to earlier weren't even on the market ten years ago in the United

States. It's hard for industrial managers and homeowners and commercial office developers to know what the most energy-efficient building practices and equipment choices are and, just as important, how reliable they are. People still will not risk their money on such new technology.

Second, the investments required are substantial, and are often beyond the means of individual businesses and homeowners. Cash-strapped businesses battered by foreign competition do not typically view energy savings as a high priority, when it lies so far outside their business. Even middle class homeowners are loathe to add insulation or buy high efficiency lighting; there are many other and more attractive uses for limited discretionary income.

Most importantly, there is simply a mismatch between energy efficiency costs and benefits. It is really society that reaps the rewards of energy efficiency, in the form of reduced need for costly and polluting new power plants. But it is the individual who is being asked to pay. The result is obvious: businesses fail to invest in energy efficiency innovations that take more than a year or two to pay back, thus forcing to society to make power plant investments that may take a decade or more to break even on economic costs alone (and may never pay back when environmental costs are considered).

The Answer: Direct Utility Investment and New England's Leadership

The public policy solution to this dilemma became clear years ago to CLF. Since electric utilities have been entrusted with a franchise monopoly to provide society's electrical needs, and since they have a unique infrastructure of contact with their customers, they are the logical implementors of energy efficiency investment. CLF's vision was that New England's electric utilities must pursue energy efficiency opportunities in their customer's homes, businesses and factories and pay for those opportunities to be implemented, just as the utility would pay for the construction of a power plant. If the utility doesn't pay for all energy efficiency opportunities which are cheaper than the costs of providing power, CLF reasoned, those investments will never be made (certainly government will not make them in this era of public fiscal austerity) and society will lose big.

Once a controversial vision, this "direct investment" approach to energy efficiency has in the last two years become broadly accepted throughout New England among utilities and their regulators alike, in large measure through a series of cases and successful settlement negotiations carried forward by CLF.

Indeed, some of the most pioneering efforts in the nation are taking place right here in Connecticut under the sponsorship of Connecticut Light & Power (CL & P).

These efforts began in a rate case CL & P had pending in late 1987. Because CL & P currently has surplus generating capacity, the company argued it should be permitted to decrease its commitment to investment in electrical efficiency. CLF intervened, and demonstrated that large-scale investment by the utility in more energy-efficiency construction and equipment in new and existing buildings and homes would reduce customer bills over the long-run. In a pioneering and far-reaching decision in early 1988, the Connecticut Department of Public Utility Control ordered CL & P roughly to double its expenditure on energy efficiency; to develop "direct investment" programs for implementation; and to develop those programs with CLF and other parties where possible.

In March 1988, CL & P agreed to a unique and statesmanlike arrangement with CLF, the state Office of Consumer Counsel and the Office of Policy and Management Energy Division. CL & P agreed to fund experts working on our behalf to assist the company in developing the ordered programs. Through collaborative effort, CL & P reasoned, more could be accomplished than through endless data wars and litigation. Even if we disagreed at the end of the process, at least we'd know what our differences were.

After two months of marathon effort, CLF, the Connecticut state agencies, and CL & P announced their agreement on the first large-scale direct investment efficiency programs in the nation. Totalling $25 million in 1989, CL & P's programs will be paying developers of new businesses and homes to build to much higher standards of energy efficiency than required by the building code. CL & P will also be paying for the installation of high-efficiency lighting, insulation, heating, cooling and ventilation and motor equipment in <u>existing</u> homes, offices, hospitals and factories. Many of these programs are designed so as to eliminate entirely any financial outlay or managerial attention from customers, since for many customers funds and staff to make and supervise such energy efficiency investments are lacking. All of these programs are projected to save energy at less than the cost of producing it; indeed, that's the fundamental design principle of the programs.

Since our May 1988 agreement with CL & P, CLF has reached agreement with 10 other retail electric companies in New England to design similar programs for Massachusetts, Vermont, Rhode Island, and New Hampshire. Those agreements are being developed even as I speak today. Some of the programs developed in those negotiations will be considerably more aggressive than CL & P's programs, since few other utilities in New England are blessed

with surplus capacity. (Even though CL & P has increased its efficiency expenditures significantly to $25 million annually, it will spend nearly ten times that amount each year until 1993 on construction of new power plants and transmission and distribution facilities). In addition, the collaborative planning process pioneered by the Connecticut DPUC, CL&P and CLF is now being replicated in somewhat different form in California and New York, while serious discussion of similar efforts are underway in Iowa and Ohio.

In aggregate, CLF estimates that New England utilities will be investing $500 million -$1.5 billion annually by the mid-1990's in direct energy efficiency improvements. Those investments will save billions each year in avoided energy bills and pollution costs. Where New England falls on this investment spectrum will depend on the resolution of a number of difficult problems, including the development of an energy efficiency engineering and installation infrastructure; the development of regulatory incentives that ensure that expenditures on lower-cost efficiency options do not erode utility profits and perhaps even bolster them; the reform of arcane regional power pool rules that encourage power-surplus utilities like CL & P to more slowly exploit their efficiency opportunities while New England as whole desperately needs efficiency savings; and the development of explicit numerical values for the environmental benefits discussed earlier in this testimony, so that these "externalities" can be added to the amount utilities are willing to pay for saved energy.

All of these problems are complex; none are insoluble. That is especially so in the new atmosphere of cooperation on this topic here in Connecticut, in New England, and indeed globally.

Possible Federal Roles

As discussed earlier, many of the more exciting advances in energy efficiency are taking place at the state level, indeed right here in New England. There are several generic areas in which the federal government could prod and support these efforts, however:

o Increasing federal research dollars for the development of energy-efficient building techniques and equipment. The high-frequency electronic ballasts referred to earlier were commercialized largely through the research and development efforts of the national laboratories. Many more such innovations would be forthcoming with modest increases in research support.

o Setting forth minimal energy efficiency investment program criteria for electric utilities. While New England utility regulators have responded aggressively to the energy efficiency

imperative and prodded utilities into large-scale efficiency investments, utility commissions elsewhere in the nation have not. A federal mandate for programs such as exist in New England would vastly accelerate this salutary trend.

o Eliminating policies that could dampen efficiency investments. Recently, the Internal Revenue Service ruled that energy efficiency investments by utilities on customers' premises can be construed in some instances as taxable income to the customer. While mistaken on principle and inconsistent (utility transmission and distribution investments to serve customers are not taxed as customer income), this ruling and other policies like it will only slow the rate of implementation of environmentally and economically sound efficiency improvements. Congress might usefully make a review of such efficiency-hindering policies and eliminate them.

Conclusion

In this brief opportunity, I have only begun to explore what CLF believes is a major piece of the solution to global warming. Utility system investment in electrical efficiency is not only good economically and environmentally from a domestic standpoint, but it is also an idea that can be exported fruitfully to the developing world where energy use imposes even more of an environmental and current account burden. I hope that this brief discussion has whetted your interest, and I would be happy to provide more information upon request.

EXHIBIT 1

Sources of CO_2

Percent of U.S. Emissions in 1987

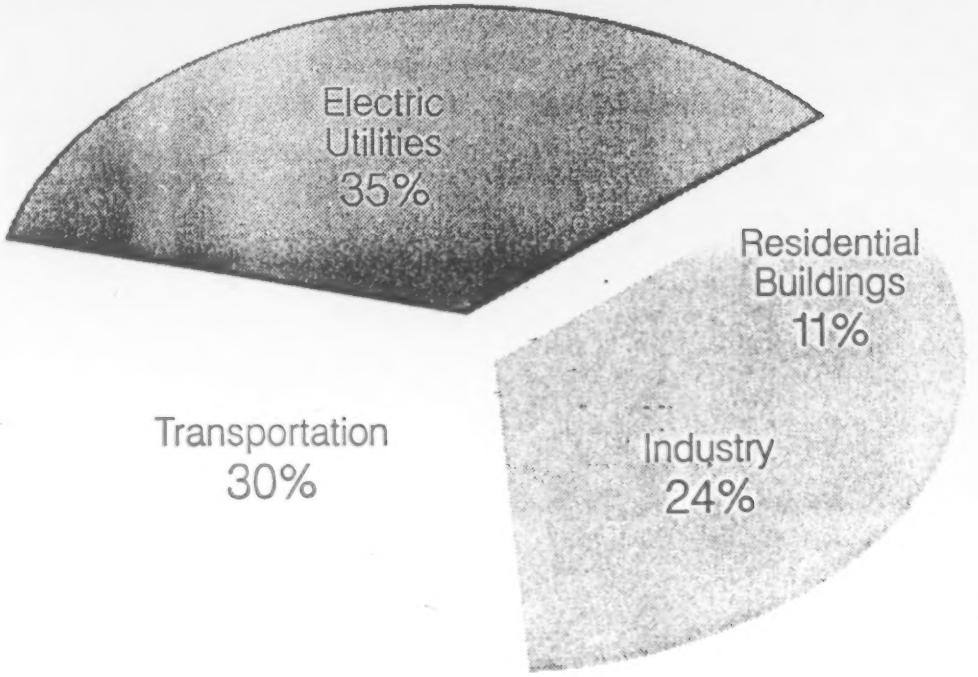

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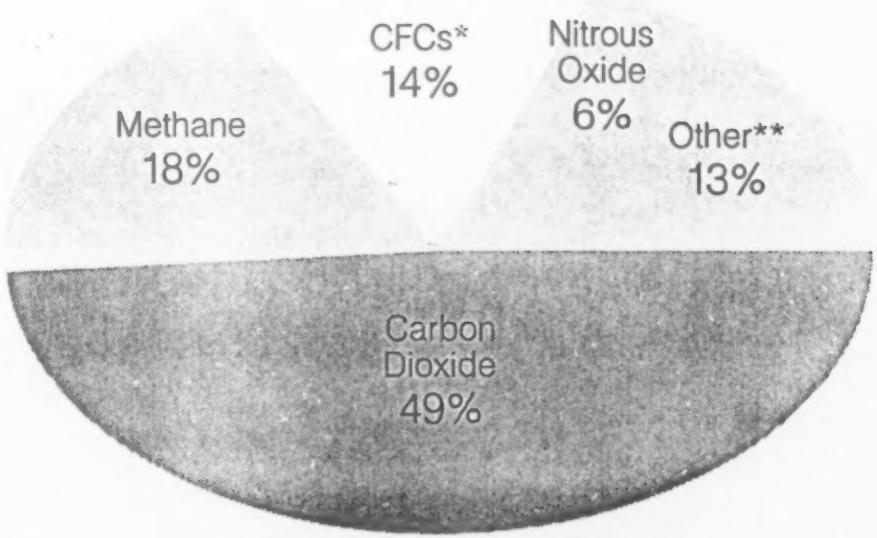
EXHIBIT 2

Relative Contributions to Global Warming

(1980's)



Source: James Hansen, et al., Journal of Geophysical Research. 8/20/88

* CFC-11 and CFC-12 ** Tropospheric ozone and other halocarbons

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EXHIBIT 3

Sources of Sulphur Dioxide

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EXHIBIT 4

Sources of Nitrogen Oxides

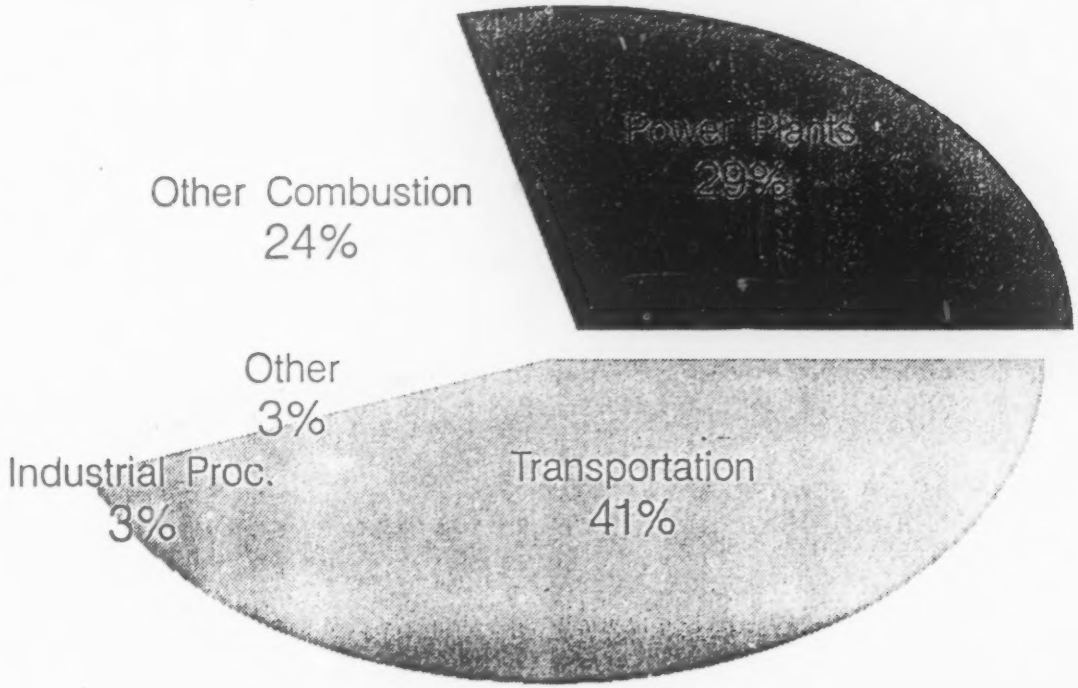

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EXHIBIT 5

Selected Energy-efficient Technologies: Current Savings and Predicted Savings at Saturation.

	Electronic ballasts	Compact Fluorescents (PL-13)[a]	Windows Low-E[b]	Refrigerators 87 Californi Title 10
. Life	35,000 hr	10,000 hr	30 yr	20 yr
. Cost Premium	$12	-0	0-$2.00/$ft^2$	$100
. Lifetime Savings per unit				
$	$100	$40	$10/$ft^2$	$1600
Energy	1000 kWh	500 kWh	1.5 M Btu/ft^2	16,000 kW
Coal(d)	1048 lb	524 lb	-	8.4 ton
Carbon as CO_2(e)	765 lb_C	382 lb_C	-	6.1 ton_C
Oil(d)	79 gal	40 gal	11 gal/ft^2	1264 gal
Carbon as CO_2(f)	469 lb_C	220 lb_C	61 lb_C/ft^2	3.5 ton_C

(a) One PL-13 replaces a series of thirteen 65W incandescents and saves 50W - 65W - 15W (includes 2W for ballast).
(b) Low-emissivity windows. Comparison assumes an overall weighted average improvement of 0.266 Btu/ft^2-hr-*F. 6000 heating degree days, and furnace efficency of 70%.
(c) Comparison based on 1987 California Title-24 Standards vs. 1977 models.
(d) Assumes an end-use heat rate of 10,970 Btu/kWh based on 10,253 Btu/kWh (EIA89) at the bus bar plus 7% T&D losses.
(e) 0.765 lb_C/kWh based on 0.73 ton Carbon/ton Coal (Rotty), and a heat rate of 20.93 Million Btu/ton (EIA89)
(f) 0.44 lb_C/kWh based on 0.78 ton Carbon/ton Oil (Rotty) and a heat rate of 38.57 Million Btu/ton of Oil (EIA89)

Table Prepared by Dr. Arthur Rosenfeld, Lawrence Berkeley Laboratory

Sources:

EIA89 - Monthly Energy Review February 1989, U.S. Dept. of Energy, Energy Information Agency, DOE/EIA-0035(89/02), May 1989.

Rotty - Ralph M. Rotty and Gregg Marland, Fossil Fuel Combustion: Recent Amounts, Patterns and Trends of CO_2, pp. 474-490, The Changing Carbon Cycle: A Gobal Analysis. Edited by J.R. Trabalka and D.E. Reichle, Springer-Verlag Publishers, 1986.

EXHIBIT 6

Source: Lawrence Berkeley Laboratory

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EXHIBIT 7

How New England Uses Electricity

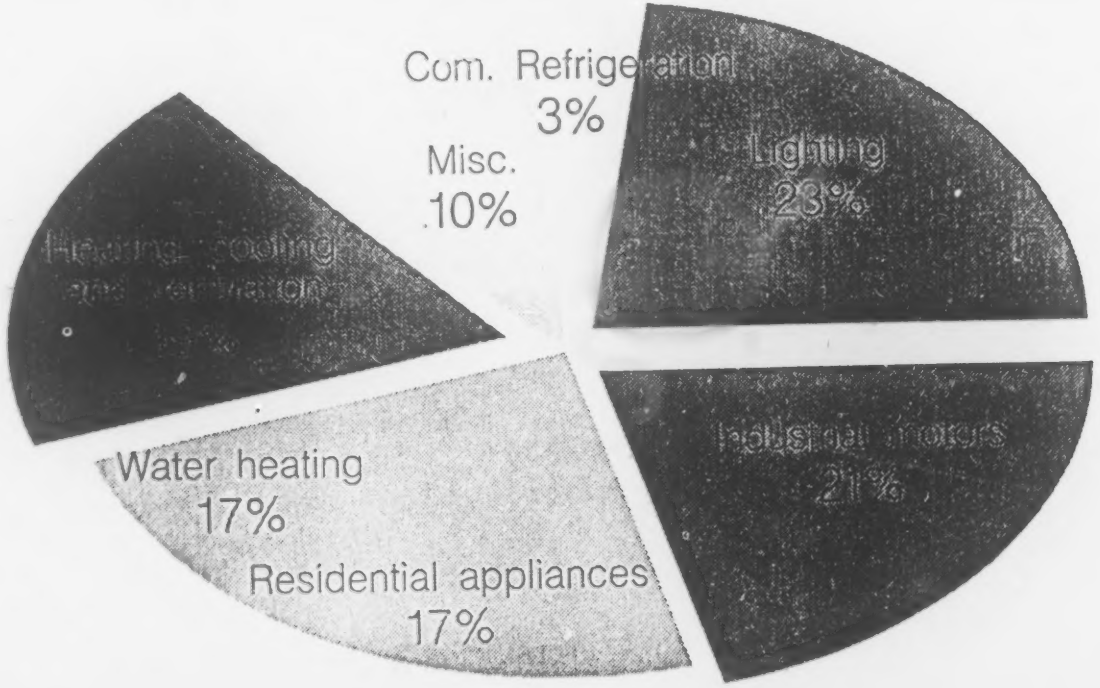

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EXHIBIT 8

Savings from Efficient Technologies

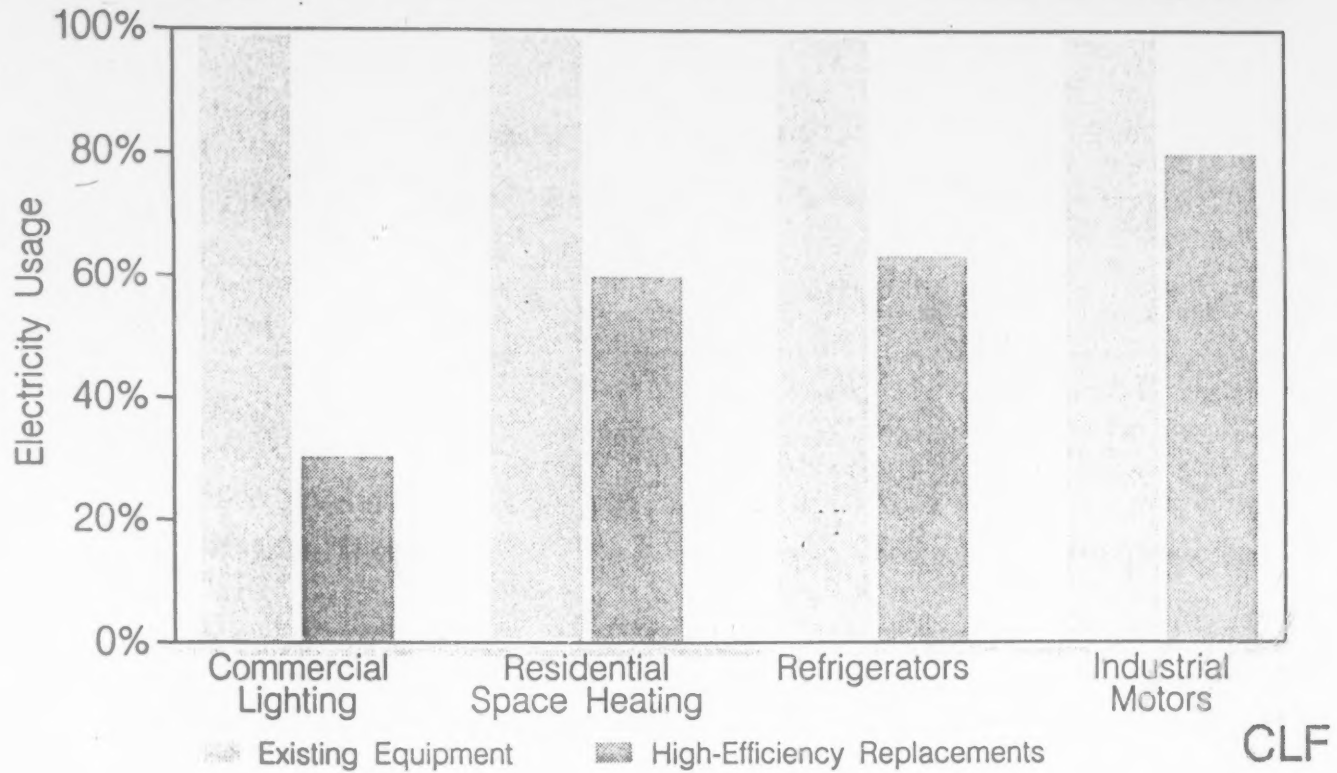

EXHIBIT 9

Technical Energy Savings Potential

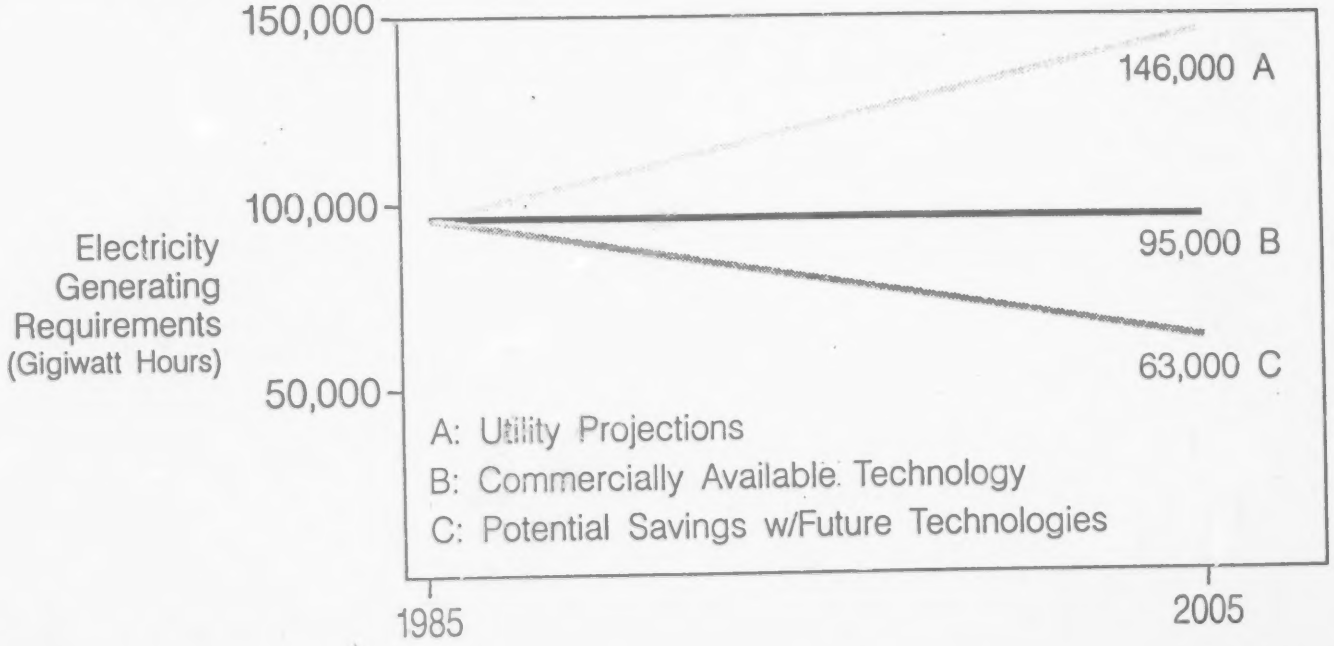

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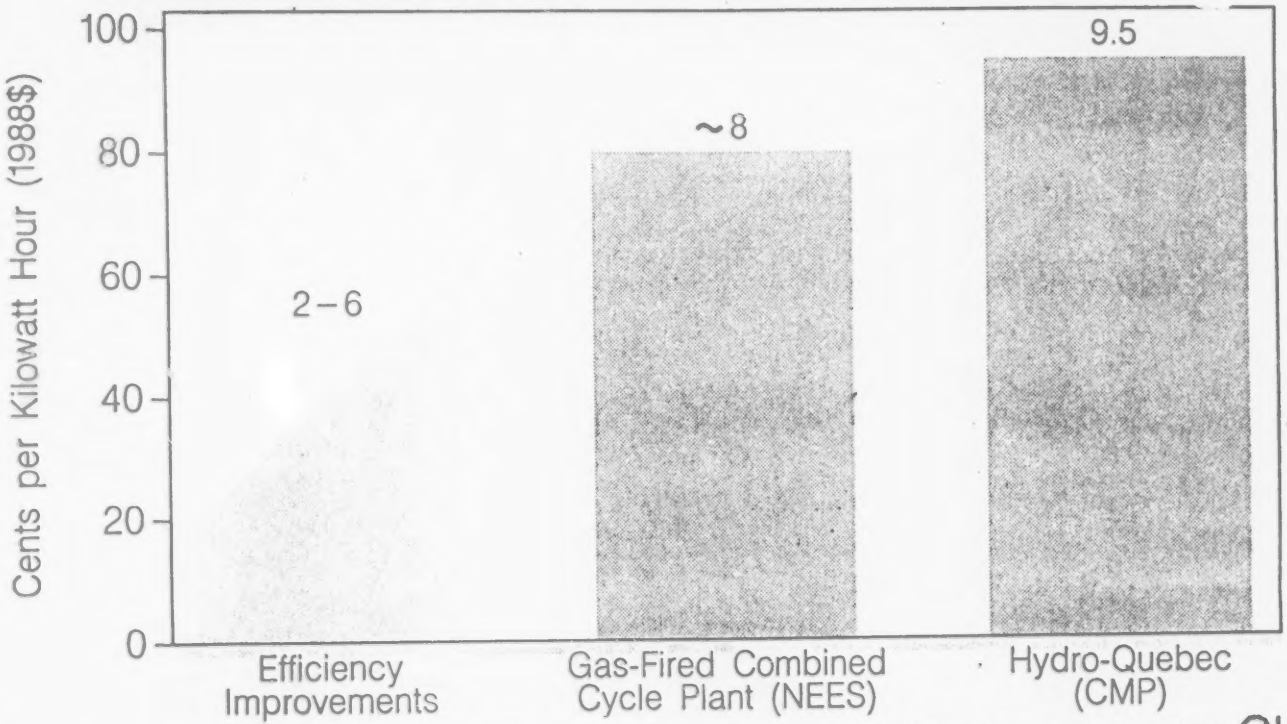
EXHIBIT 10

Electricity Production Costs*



* Additional costs of line losses and reserve requirements not included for generation options

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TESTIMONY OF
JAMES F. MEEHAN, CONSUMER COUNSEL
OF THE OFFICE OF CONSUMER COUNSEL

BEFORE THE
SENATE ENVIRONMENT AND PUBLIC WORKS COMMITTEE
ENVIRONMENTAL PROTECTION SUBCOMMITTEE

AUGUST 10, 1989

Good morning Senator Lieberman, my name is James F. Meehan and I am the State Consumer Counsel for the State of Connecticut. I appreciate the opportunity to address the subcommittee on the issues of global warming and energy efficiency. It is appropriate that your subcommittee hold hearings on these issues out of Washington, DC given the plain fact that much of what is going on in this country that is positive in the area of energy efficiency and steps to combat global warming is taking place out of the belt-way of our nation's capital. Connecticut, New England and other states have taken up the mantle of energy policy that was unfortunately dropped by the Federal government beginning in 1980.

Today's expenditures for research and development on energy conservation by the federal government are only 25-35% of the levels expended prior to President Reagan taking office. The green house effect was created in part by the "white house" effect which led

our nation to an abandonment of any principles of active federal involvement in planning a national energy policy. The short shrift given to the development of conservation technologies reduced our nation's ability to respond to the challenges of a volatile world energy market. We have demonstrated an ability with the proper policies to curtail energy consumption. Energy conservation undertaken by the industrial countries beginning in 1974 resulted in no growth in energy consumption between 1974-1984. The world response to rapidly increasing energy prices was remarkable. Energy savings from this world-wide conservation effort resulted in excess of $150 billion a year. Oil and gas savings through improved efficiency saved over 14 million barrels of oil per day or half the capacity of OPEC. Conservation and the programs undertaken by the Carter Administration led to the dramatic drop in consumption and the eventual demise of OPEC. The collapse of energy prices and our new national energy policy established by the Reagan Administration has resulted in renewed growth in energy consumption beginning in 1985 that has kept pace with the growth in the gross national product for the industrial nations. If this trend continues, we will no doubt experience global warming and adverse economic consequences. While we commend Congress for resisting the recent effort by the Bush Administration to reduce by 50% the Department of Energy Conservation R&D budget, more needs to be done than giving an inflationary increase to an already reduced program effort.

Improving energy efficiency is rewarding not only in the pocket book, but also for our environment. A little conservation and efficiency improvements goes a long way.

- If gasoline powered vehicles use 26 mpg the use of oil will be reduced by 5 million barrels of oil a day or 2.5 Alaskan production or 500 oil platforms;
- Lighting uses one hundred 1000-mw power plants, a 1% improvement saves a plant or 1000-mw;
- Residential appliances efficiency improvements above the NAECA standard by 2% can avoid 1000 mw;
- A 1% improvement in commercial building envelopes can save 1000 mw;
- 100 million urban trees and light surfaces can save 50GW of electric capacity; and
- A home adding three trees, white paint and white sand can save 1kw capacity.

Many experts agree that the green house effect can be avoided by maintaining our energy consumption levels constant. This can be accomplished within the parameters of existing technologies which are either in the marketplace or in development. However, this goal cannot be accomplished without effective national leadership. In Connecticut we have taken steps to advance energy conservation. Through lengthy and contentious litigation the Office of Consumer Counsel, the Office of Policy and Management and the Conservation Law Foundation were successful in convincing the Department of

Public Utility Control to begin an aggressive energy conservation program for Connecticut Light and Power Company. While this process has proceeded with much less fanfare than accompanies most matters we get involved with CL&P, this is the most significant regulatory decision in my tenure and has become a model for the cooperative development of effective energy programs not only here in New England but throughout the United States. The programs are designed to attack many problems. Efficiency investments are being used to make Connecticut industry more competitive. Low income households energy bills are being contained through targeted conservation. Commercial buildings are being redesigned to provide for energy efficiency into the next century. The program is even being used to rescue the family farms in Connecticut which are in jeopardy due to the depressed farm economy. Connecticut Light and Power Company should be congratulated on its response to the DPUC's orders and has become a leader in this area. However, much more needs to be done in Connecticut.

Efficiency investments must be improved from the existing expenditures by Connecticut Light and Power Company of approximately $27 million a year to over $40 million a year for the next number of years. We will be calling for an increase in our commitment beginning in 1990. Natural gas utilities and oil dealers must also be required to enter in a meaningful fashion into the conservation arena. These are initiatives that can and will be accomplished on

the state level. Nonetheless, the problems that we face are national in scope and require renewed actions by the federal government.

We would recommend that your Committee consider the following to recast the national energy policy:

- Increase by 20% per year the energy efficiency budget of the Department of Energy;
- Establish regional compacts to manage and co-ordinate energy efficiency programs and overcome regulatory obstacles to carry out energy efficiency programs;
- Provide for direct federal funding and support for collaborative energy efficiency programs and to fund demonstration projects and advance the development and deployment of energy saving technologies.
- Remove any federal disincentives to energy efficiency such as the recent ruling by the Internal Revenue Service to tax efficiency investments;
- Create a national data base on the demand side management programs; and
- Enhance and expand the role of the national energy laboratories to establish branches within the regional energy compacts to assist with the technology deployment.

The focus of the new national energy policy should be to take advantage of the initiatives demonstrated by the States. We do not want to repeat the mistakes of the 1970's when many programs were out of control. Utilities, regulators and energy planners have tailored the programs to gain acceptance with the consumers. These

programs are the building blocks upon which a national energy program can be built. Use what is already in place. The regional administration of the national energy policy makes sense. Each region should be required to establish a compact to co-operate in energy planning. All new federal dollars for energy efficiency should be administered by these regional compacts and the States. The expansion of the national energy laboratories through regional offices will provide the know how and technical support necessary to support a meaningful expansion of the federal role in energy planning. The recent relevation of the green house effect was a wake-up call to the Country. Hopefully, the concern expressed on the global warming issue will lead to a jump start of our national energy policy. The problems we face are challenging, but well within our ability to resolve.

In closing I would like to thank you for responding so quickly to our recent letter asking for your assistance in seeking to turn around the Internal Revenue Service on its new policy of declaring energy efficiency investments by utilities to be included as taxable income to consumers. This, as you have recognized, could have a devastating effect on our effort to expand these programs. At the very least the federal government should not be an obstacle to conservation programs. Teddy Roosevelt's Woodsman Prayer would be appropriate in this case. When a woodsman was facing a charging grizzly bear he prayed, "Oh lord please help me slay this b'are. But lord if you don't help me, please don't help the b'are."

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TESTIMONY

by

ROGER LITTLE
SOLAR ENERGY INDUSTRIES ASSOCIATION

before

SENATE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS
SUBCOMMITTEE ON ENVIRONMENTAL PROTECTION

on

SOLAR ENERGY AND THE ENVIRONMENT
SOLAR CONTRIBUTIONS IN THE 1990S AND BEYOND

AUGUST 10, 1989
HARTFORD, CONNECTICUT

Prepared by Scott Sklar
Executive Director
Solar Energy Industries Association

INTRODUCTION

In June 1989, the U.S. Environmental Protection Agency (EPA) and the U.S. Export Council for Renewable Energy (US/ECRE), a coalition of the nine national renewable energy trade associations formed to promote exports of alcohol fuels, geothermal, hydropower, passive solar, photovoltaics, solar thermal, wind and wood energy, hosted a Forum on Renewable Energy and Climate Change. The leaders of this nation's private sector renewable energy companies gathered in Washington, D.C. to advise EPA on the potential "real world" contributions our industries could make in a business-as-usual scenario or an enhanced scenario. The presentation of SEIA manufacturers, project developers and component suppliers in both the solar thermal and photovoltaics industries (attached) shows that under enhanced conditions, active solar water heating, photovoltaics, and solar thermal utility-scale plants could meet 6.75 quads by the year 2000. In a business-as-usual scenario, our industries will barely make 2.1 quads by the year 2000.

The Solar Energy Industries Association (SEIA), the national trade organization of the passive solar, photovoltaics and solar thermal manufacturers and component suppliers, believes that greater use of solar energy can cost-effectively meet our nations environmental challenges while creating jobs and exports. As president of Spire Corporation (Bedford, MA), a leading manufacturer of photovoltaic manufacturing equipment, and as SEIA's representative on US/ECRE of which I serve as Chairman of the Board, I am in a unique position to provide the Subcommittee on the capabilities of the U.S. solar energy industries.

The United States policy regarding solar and renewable energy over the last decade can be best characterized as "benign neglect". While our country left this void in development, our international competitors aggressively stepped in to such an extent that the United States may import all of its solar energy technologies by the year 2000 and lose our world markets as well. Why would the United States, after investing and holding the technological lead in all the solar technologies, allow our competitors to commercial our inventions and reap the hundreds of millions of dollars in profits and thousands of jobs in solar energy?

While the Carter Administration policies may have caused over expectation in what solar energy can accomplish, the Reagan Administration discounted any contribution, even though our aggregate sales for solar approach $1 billion per year. While the rhetoric from the Bush Administration has been more favorable, our industry is concerned that fine rhetoric and no action can have the same sad result, the United States continues to lose domestic and world market share and the action shifts to our international competitors. At present

U.S. Energy policy is still fixated on conventional energy and not the technologies that will maintain U.S. energy security and leadership in the twenty-first century.

With increased oil imports, increased environmental degradation, and increased usurpation of the solar industry in international markets, it's time for the Department of Energy to reassert itself in energy policy and take some proactive steps to build a viable and growing U.S. solar energy industry.

STATE OF SOLAR INDUSTRY

Photovoltaic, the conversion of sunlight directly to electricity, has come down ten-fold in costs in the last decade while efficiency has increased four-fold. Photovoltaic sales topped $150 million in 1988 with 65 percent of U.S. photovoltaic equipment exported to the developing world to provide power for medical refrigerators, water pumping and irrigation, communication, and lighting. Many of the utilities in the United States are looking towards photovoltaics to provide remote power in the utility service area for sign and street lighting and even to country homes. Photovoltaics for utility peak power will be seen before 1990 if the tax incentives are maintained, for there are several privately-financed projects in the pipeline now. In 1989, photovoltaic sales are expected to increase by 25 percent.

Solar water heating is the most common solar technology in the market place. Over one million homes in the Untied States use solar water heaters. While that sounds like a large number of solar applications over the last fifteen years, the City of Tokyo alone has an equal number of solar water heaters. Most of the solar water heaters are rated by the Solar Rating & Certification Corporation (SRCC), a non-profit organization established by the solar industry and state government energy officials. SRCC has developed a solar system certification that meets the HUD Minimum Property Technical Standards. In 1988, SEIA/ASHRAE with support of the U.S. Department of Energy has published a commercial-scale design manual which draws form over ten years experience of the industry and federal research, to show the best way to design large-scale, cost effective, commercial solar projects. In 1989, sales are expected to increase by 15 percent.

Solar thermal power, which concentrates sunlight to create steam, which in turn can be used to generate electricity is cost effective today. The United States has the largest privately-financed solar thermal power facilities generating 200 megawatts of utility-grade electricity in California. Over 500 megawatts will be generated over the next two years with costs already below that of nuclear energy generation. In 1989, sales are expected to increase by 50 percent.

After years of research, solar energy is finally being commercialized. Ten federal policy options, most of which will cost no money, should be adopted to promote the use of solar energy and decrease pollution by conventional energy sources.

TEN U.S. POLICY OPTIONS TO BUILD A U.S. SOLAR INDUSTRY

Half of these options will not increase the federal deficit in any way, and the other five options, in aggregate, will not surpass federal support for the conventional energy industries.

1. Use of the " bully pulpit" of the Presidency to promote solar energy -- Both the President and the Secretary of Energy, though speeches and site visits, can encourage government, commercial and residential consumers to utilize solar energy which will build confidence in the consumer and investment communities. Increase in federal spending: $0.

2. Allow solar-electric applications to be used in situation where the Clean Air Act limits new electric production -- Why shouldn't a utility be able to build solar energy plants which have no emissions? Increase in federal spending: $0.

3. Incorporate regulations for easier loans/mortgages from FHA/VA/FmHA when solar energy applications (passive solar, photovoltaics, and solar thermal) are installed in the building -- Use of solar lowers energy bills allowing the owner to have more expendable income and thus more easily afford the mortgage/loan. Increase in federal spending: $0.

4. Solar energy research and development must be maintained by the United States -- Minor increases in solar energy R&D in international, photovoltaics, solar building and solar thermal must be enhanced to insure that technology developed in the 1980' actually reach the marketplace. Increase in federal spending: $20 million.

5. Taxes on electric production to offset acid rain should have set-asides for solar and renewable energy -- Proposals to tax fossil fuels use in electric production should include a 15 percent set-aside for utility incentives to build solar and renewable energy plants which would directly offset coal burning Increase in federal spending: $0. (New fee, off budget).

6. Continue the 10 percent solar energy business tax credits which are due to expire on December 31st. -- This small incentive buys down the risk for commercial customers of solar energy which has been essential for commercial customers of solar energy which has been essential for the private sector surpass 200 megawatts of utility-scale power, and if passed will attract capital for another 300 megawatts by 1991. Increase in federal spending: $25.0 million.

7. Require passive and active solar applications in all new federal buildings and create incentives for third-party financing of solar-electric plants -- Since the federal government is the largest energy user and largest building builder and owner in the United States. Increase in federal spending: $0 (Energy savings alone will make up for increased outlays for solar equipment, materials, or tax preference for 3rd party investors).

8. Lower cost of capital for utilities and private companies to build utility-interconnected solar plants by providing a subsidized loan program to lower front-end capital costs. Such bold action will allow utilities to justify new plants before State Utility Commissions and to their investors. A similar program should be developed for residential consumers using the oil overcharge and stripper well funds distributed to state governments. Increased federal spending: $50 million per year for ten years for utility applications, $0 for residential since these are now counted as off-budget expenditures.

9. Allow federal-set-asides for solar and renewable energy electric power plants under 150 megawatts under the Public Utility Regulatory Policies Act (PURPA) -- By allowing solar plants a waiver from bidding and increased regulatory costs, use of solar plants for peak power become the energy of choice. Increase in federal spending: $0.

10. Provide export set-asides for solar equipment through the Export-Import Bank, Overseas Private Investment Corporation, Trade & Development Program, as well as the World Bank and the three regional development banks. Currently these institutions invest most of their energy money for diesel and coal use in the Third World making them more reliant on energy imports and less able to pay their debts. Increase in federal spending: $0.

In total, for less than $100 million per year (which in less than one-third of the fission or fusion federal R&D program) the United States could have a thriving solar industry providing more than six quads by the year 2000 and with export sales over $2.5 billion.

CONCLUSION

The Administration's recommendation of a 30% in photovoltaics and a 20% cut in solar buildings and solar thermal R&D for FY'90, and the House Ways & Means Committee's action not to extend the expiring commercial solar credits must be turned around this year.

In order for the U.S. solar energy industry to increase world market share, the industry must increase the domestic market. Low-cost incentives promoting residential and commercial use of solar credits must be adopted this year. In order for the U.S. solar energy industry to increase world market share, the industry must increase the domestic market. Low-cost incentives promoting residential and commercial sue of solar energy, federal procurement, and utility-scale generation are necessary. New incentives would not cost more than $100 million per year and many would save consumers and the federal government millions within a decade.

Aggressive use of solar applications to offset pollution is essential. Incentives which lower the risk and increase practical applications make the most sense. Our international competitors understand the need to implement policies to build domestic markets and cut oil imports, why can't the United States?

Japan and Germany surpassed the United States for the first time in federal research & development spending for photovoltaics. Why doesn't the United States see this as signal to overtake us in this technology. Japan and Germany and other are using concessionary financing and tied aid to promote their exports of solar energy equipment in the Third World. Why doesn't the United States see this as an attempt to overtake the United States in the export markets?

If the United States is not vigilant, not only will will our petroleum imports surpass 50 percent in the 1990s but our solar imports may surpass 50 percent by the year 2000 from the very countries we import cars and VCRS's. Such an outcome would be a tragedy.

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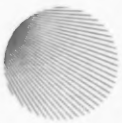
RENEWABLE ENERGY TODAY & IN THE 1990'S

Solar Thermal Heat and Power, Solar Building Systems, and Photovoltaics

presented by

Scott Sklar, Executive Director, Solar Energy Industries Association

Presented at the Forum on Renewable Energy and Climate Change
June 14-15, 1989



The Solar Energy industry is rapidly evolving into a mature competitor for energy production as we approach the 1990s. Long considered a technology of the future, solar energy has proven itself as a viable resource for today as well as the future. Not only do we find a potentially limitless supply of this natural resource, but we also see minimal environmental consequence. As the greenhouse effect and acid rain plague the electric utility industry and the nation as a whole, the need for efficient and benign energy is essential. The combined efforts of photovoltaic, solar building heating and cooling, and solar thermal power technologies can play an integral part of the energy demand of the future.

Photovoltaic (PV) cells convert sunlight directly into electricity. When sunlight shines on a cell, containing a semiconductor material made of silicon, electrons become excited and free themselves from the semiconductor material, creating an electric current. Cells are usually connected in series on a flat surface to form what is called a flat-plate module. A concentrator is a type of module that uses lenses to concentrate the sunlight onto the cell. This reduces the number of cells required and increases efficiency. Also, two or more semiconductor materials, each designed to absorb different parts of the solar spectrum, can be stacked to attain even greater efficiencies.

While most PV applications are currently in remote areas where conventional electrical energy is either impossible or too expensive, recent advances in production technology and PV efficiency have greatly improved the prospect of large-scale PV use. In addition, PV's produce electricity with no carbon dioxide emission or fuel costs, and have a module failure rate of only 1/10 of 1%. Due to these advantages, United States photovoltaic sales have reached $175 million per year, with an industry of approximately 15 U.S. manufacturers.

The PV industry currently produces enough electricity to displace .0003 quads of conventional energy (.0298 billion kWh) and displace .0195 million tons of carbon dioxide emissions each year. (see figure 1) In a "business as usual" scenario, by the year 2000, PV's will displace .0210 quads of energy (2.0286 billion kWh) and 1.4933 million tons of carbon dioxide per year. (see figure 2) In an enhanced scenario, by the year 2000, PV's will displace 2.6 quads of energy (251.16 billion kWh) and 184.890 million tons of carbon dioxide per year. (see figure 3)

Solar building technologies capture and convert sunlight through discrete collection, storage, and distribution equipment (active systems), or by using the building structure itself (passive systems). Active systems use mechanical fans and pumps to assist in the storage and

distribution of heat from the sun, which include solar water heating systems and enhanced ventilation systems. Passive building design incorporates southern window sizing and exposure to maximize the winter sun for heating, and materials and design such as large overhangs and shade trees to minimize summer air conditioning. Solar Building technologies includes the utilization of sunlight for interior lighting (daylighting systems). Today's solar systems can contribute significantly to a building's space heating, hot water, cooling, and lighting requirements at competitive costs. Over one million U.S. homes use solar water heating which equals the number of solar buildings in the city of Tokyo alone.

In 1881, Clarence Kemp patented the Climax solar water heater. In 1909, William Bailey introduced thermal storage to his copper collectors calling it the Day and Night System. Bailey later introduced a closed loop heat exchanger system that prevented pipes from freezing and bursting. Over the next eighty odd years active systems of all kinds have been perfected for the residential, commercial, and industrial usage. The U.S. solar water and space heating industry incorporates approximately 30 companies involved in the manufacturing of flat-plate collector systems, pool heating collectors, ICS and thermosiphon units, and evacuated tube collectors generating $65 million dollars in annual sales.

George and William Keck built a passive home in 1940 for real estate developer Howard Sloane and caught the attention of America. The interest in solar homes was stimulated by the need to conserve energy during World War II, and again during the oil embargo of the 1970s. The passive systems industry is not a precisely defined group of individuals and firms, but rather an ideological approach to design and building. Certain manufacturers of efficient glass, insulation, storage and distribution of heat technologies can be considered to be within the passive solar industry, while manufacturers of raw materials could not be considered within the industry. Roughly 200,000 homes are considered to be passive design, and over 1 million homes incorporate at least one aspect of passive technology.

In 1988, Solar Building technologies displaced 0.052 quads (5.023 billion kWh) of energy, which would emit 3.3831 million tons of CO2. (figure 1) Under a 'business as usual' scenario, where no federal or state policy was implemented to increase the utilization of this conservation technology, 1.76 quads (170 billion kWh) of energy and 125 million tons of CO2 are displaced in the year 2000 by Solar Building technologies. (figure 2) However, by the year 2000 under an 'enhanced scenario' where federal and state policy placed incentives upon conservation and environmentally benign

energy sources, we could displace 2.25 quads (217.35 billion kWh) of energy and 160 million tons of CO2 per year by utilizing Solar Building technologies. (figure 3) Since over 35% of U.S. energy is used for heating or cooling buildings, active and passive solar technologies have great potential in offsetting fossil fuels.

Solar thermal electric power plants convert radiant energy from the sun into electricity. By focusing the sun's rays on to a working fluid, which in turn converts water to steam and turns a conventional turbine, solar thermal power plants can produce electricity with little or no carbon dioxide emissions. The first solar energy plant can be traced to the early 1960's, when a Russian scientist used mirrors mounted on railroad cars to heat a tank of water. Since then a variety of solar thermal electric power designs have been employed, most of which can be placed into three main categories: central receivers, parabolic dishes, and parabolic shells.

Central receivers work much like the Russian railcar plant. Fields of tracking mirrors, called heliostats, direct sunlight onto a single tower-mounted receiver, which transfers the heat to water which boils and turns a conventional steam turbine. Parabolic dishes track the sun and focus the sunlight on to an engine located at the focal point of the dishes. Engines, are able to generate electricity directly at the focal point of the dish, making them highly efficient.Parabolic troughs use tracking collectors that concentrate sunlight onto a receiver tube that runs along the focal line of the trough. Currently, parabolic troughs are the most cost efficient of the three solar thermal electric technologies, and the only one that is in large scale commercial use.

The solar thermal electric industry contains 35 companies and have annual sales of $200 million. Luz International, who produce an estimated 90% of the world's solar generated electricity, produces 200MW of solar generated electricity using parabolic troughs, and plans to expand to 1000 MW by 1995.

Presently solar thermal power plants produce .005 quads of energy (.48 billion kWh) and displace .3253 million tons of carbon dioxide emissions each year. (figure 1) In a "business as usual" scenario solar thermal power will produce .0270 quads of energy (2.61 billion kWh) and displace 1.92 million tons of carbon dioxide by the year 2000. (figure 2) However, in an enhanced scenario, by the year 2000, solar thermal power could produce as much as 2.00 quads of energy (193.2 billion kWh) and displace 142.222 million tons of carbon dioxide a year. (figure 3)

Although the U.S. solar energy industry is less than 15 years old, the potential for solar is profound. Sales are up in all three solar sectors, sunlight is everywhere, and costs continue to drop. Solar sales should increase from $440 million to $1.675 billion by the year 2000 in the United States alone.

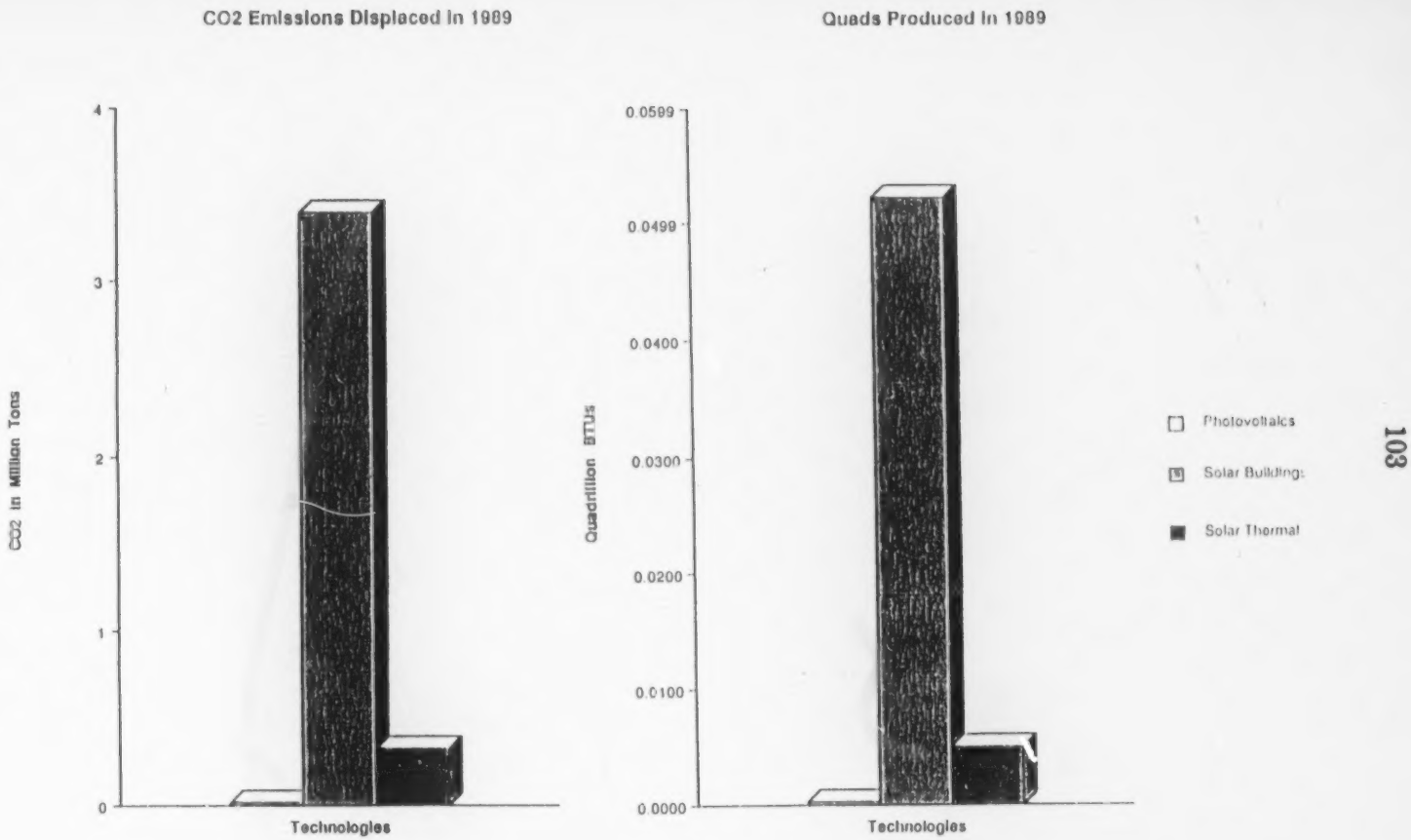

CO2 Emissions Displaced in 1989
CO2 in Million Tons
4
3
2
1
0
Technologies
Quads Produced in 1989
Quadrillion BTUs
0.0599
0.0499
0.0400
0.0300
0.0200
0.0100
0.0000
Technologies
Photovoltaics
Solar Building
Solar Thermal

Figure 1

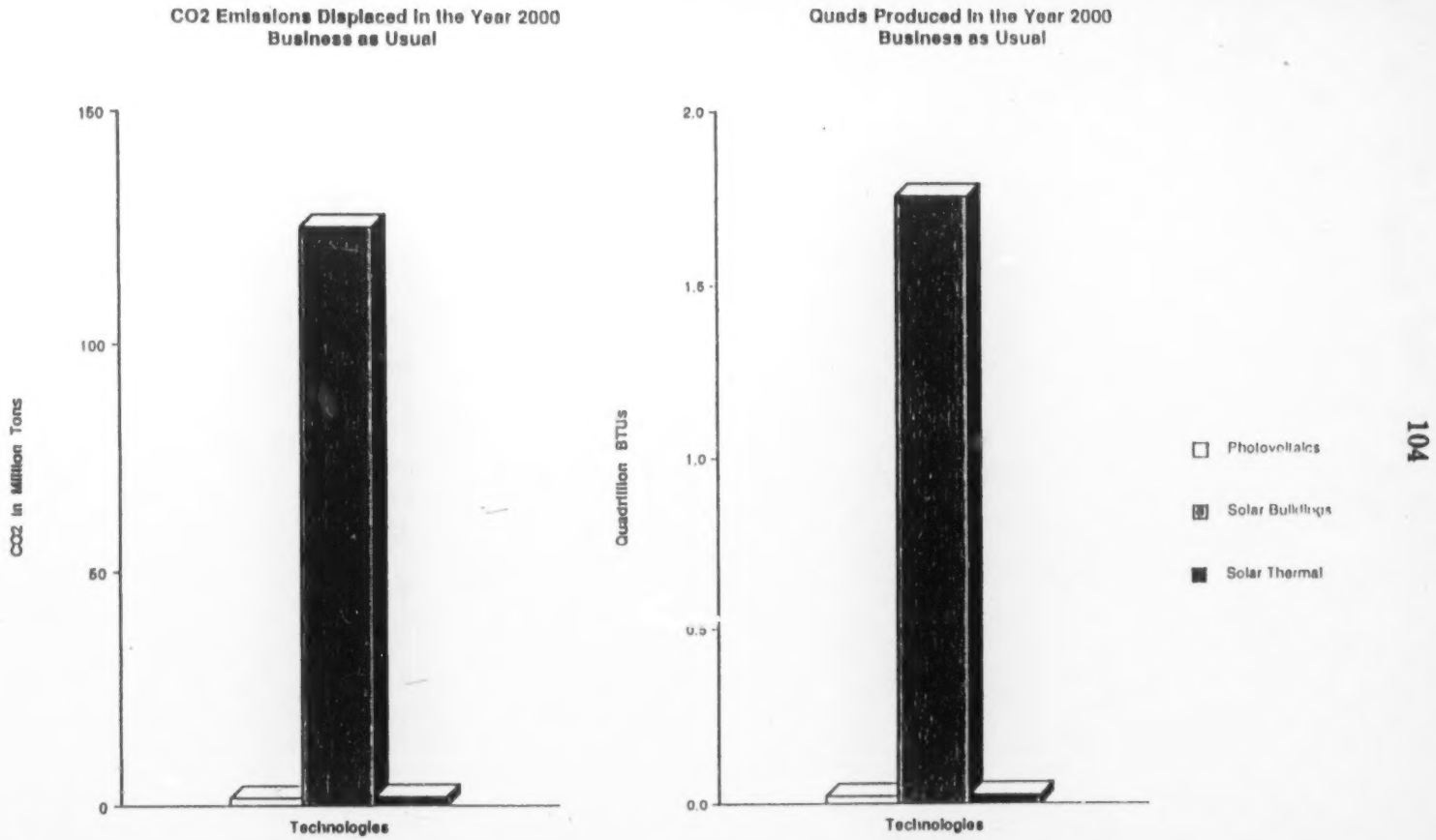
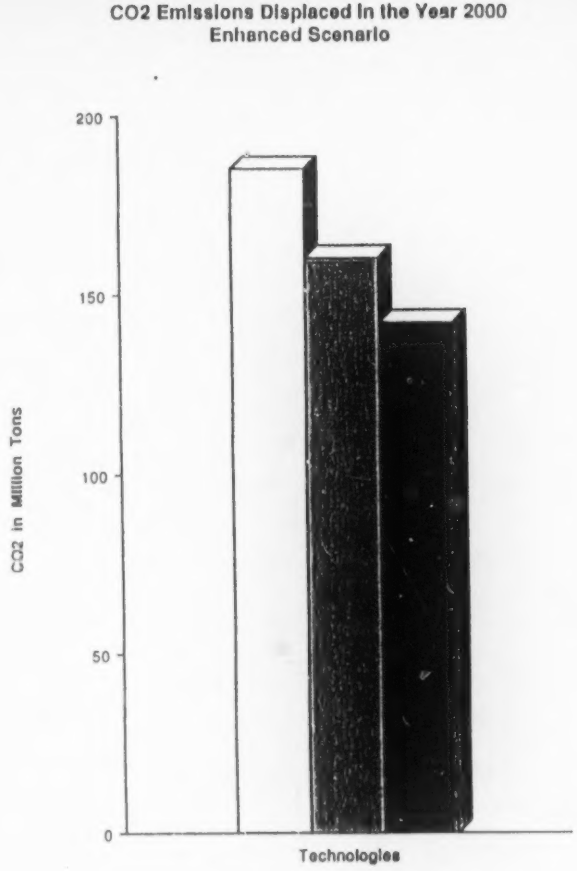

CO2 Emissions Displaced in the Year 2000
Business as Usual
CO2 in Million Tons
150
100
50
0
Technologies
Quads Produced in the Year 2000
Business as Usual
Quadrillion BTUs
2.0
1.5
1.0
0.5
0.0
Technologies
Photovoltaics
Solar Buildings
Solar Thermal

Figure 2


CO2 Emissions Displaced in the Year 2000
Enhanced Scenario
CO2 in Million Tons
200
150
100
50
0
Technologies

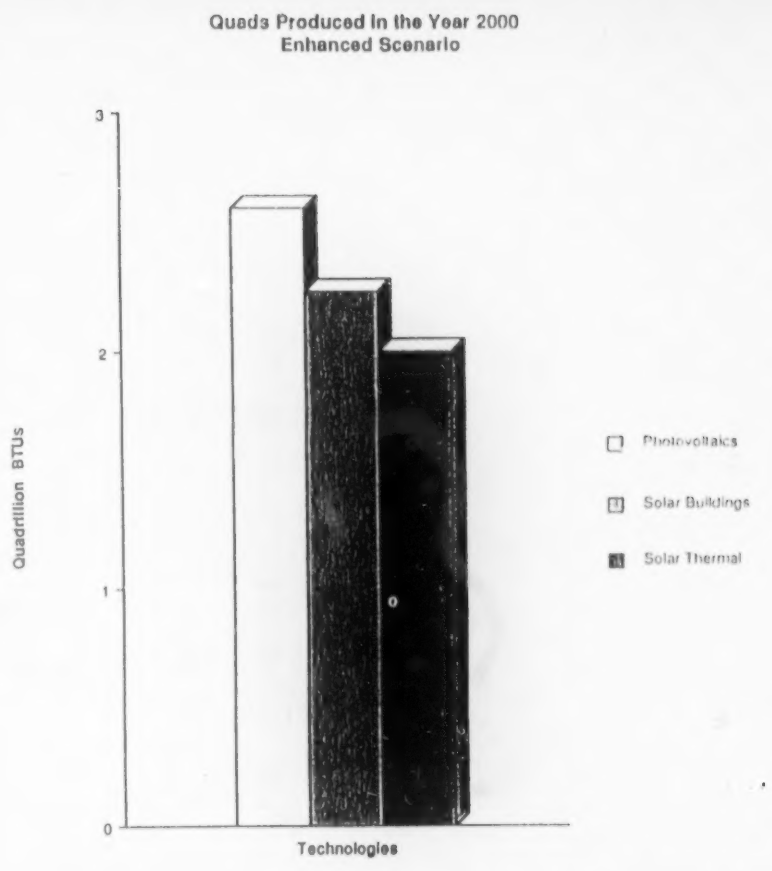

Quads Produced in the Year 2000
Enhanced Scenario
Quadrillion BTUs
3
2
1
0
Technologies
Photovoltaics
Solar Buildings
Solar Thermal

Figure 3

STATEMENT
OF
DONALD R. GLENN
VICE PRESIDENT
ENERGY RESEARCH CORPORATION
DANBURY, CONNECTICUT

TO THE

UNITED STATES SENATE
COMMITTEE ON THE ENVIRONMENT AND PUBLIC WORKS
ENVIRONMENTAL PROTECTION SUBCOMMITTEE
SEN. MAX S. BAUCUS, CHAIRMAN

FIELD HEARINGS ON
GLOBAL WARMING-
IMPLICATIONS FOR ENVIRONMENTAL CONSERVATION AND EFFICIENCY
HARTFORD, CONNECTICUT

AUGUST 10, 1989

Statement by

Donald R. Glenn
Vice President
Energy Research Corporation
Danbury, Connecticut

SUMMARY - Energy and Environmental Situation

- Connecticut is not a major polluter while the U.S. Northeast Quadrant accounts for 62% of total SO_2 and 45% of total NO_x exhausted to the atmosphere.

  Message:
  Connecticut receives polluted air from Northeast States located west of the State.

- Connecticut (and New England States) are dependent on imported oil and natural gas for over 50% of generation capacity. Only Texas consumes more, but oil is from domestic sources.

  Message:
  New England (including Connecticut) must reduce or replace use of high priced oil to be less vulnerable to political uncertainty of OPEC sources.

- Northeast electrical use in 1987 increased 4.9%, 3.1% above previous forecasts. The ten-year forecast for the New England Power Pool shows only a 10% capacity margin in 1997 assuming Seabrook 1 is in full operation. This is the lowest margin projected for any US region based on summer peaks and is below the requirements for the region's reliability criteria.

  Message:
  Present use exceeds projections; future demands exacerbate almost certain shortages already predicted.

- New England Power Pool is projected to be second largest electrical energy importer by 1997. (California is largest.)

New England is in a very precarious position, possibly the worst of any US region. Out-of-state generated air pollution, heavy reliance on imported oil, natural gas and electricity coupled to deficient regional generation reserve margins beginning in 1993 bodes badly for our area.

SUMMARY - Fuel Cell Contributions

- Fuel cells coupled to either coal gasifiers or natural gas produce the highest electric efficiencies attainable by any known generator.

  Impact:
  Fuel cell based generation will exhibit reduced CO_2 production directly proportional to efficiency differences from other generators and will result in conservation of energy resources.

- Fuel cell power plants are environmentally benign producing very low or no SO_2 or NO_x pollution while operating quietly. Being factory assembled and truck/rail transportable, rapid installation and start up are possible.

  Impact:
  Siting considerations are only dependent on area and volume issues. Fuel cells can be placed anywhere exclusive of all but physical limitations. Site erection and system installation/start up are accomplished rapidly and minimize lead time requirements.

- o Being inherently modular, fuel cell systems adapt to load growth planning with proportionate capital investment. Further, phased additions to generation capacity can integrate with economies of scale, i.e. coal gasification/dual fuel systems.

  Impact:
  Equipment useful life is not sensitive to capacity limitations, thus fuel cell power plants remain vital during plant growth to central station-sized missions.

- o Fuel cell modularity coupled to overload flexibility minimizes effect of unscheduled maintenance events. Fuel cell stacks can be replaced with little or no effect on overall plant availability as remaining stacks can compensate for inoperative portion until the maintenance response is concluded.

  Impact:
  Fuel cell power offers high plant availability and minimized downtime to restore system.

ERC estimates that coal fired MCFC's supplying one third of the nation's requirements for new and replacement power in the 1998-2010 period could reduce SO_2 and NO_X pollution levels by 30 million tons respectively over existing present day coal burning technology. Further, carbon dioxide reductions of 2 billion tons would be realized.

DETAILED STATEMENT

The Northeast U.S., specifically New England, has been the victim in the development of U.S. energy and industrial capabilities in a way only now becoming definable. That is, the New England states are dependent on natural gas and oil for producing over 50% of their electrical generation (Reference 1). Both are higher cost in that New England imports natural gas from the producing states in the South and oil from OPEC. Being at the end of both "pipelines" their fuel costs are among the highest in the U.S. Exacerbating this, projections of electrical demands for the ten year period ending in 1998 indicate that generation reserve margins will be only 10%, (Reference 2) the lowest in the U.S. and below the supply reliability criteria starting in 1993. This assumes the Seabrook nuclear plant joins the power pool, a situation not currently assured. In addition, these projections have generally underestimated the growth actually occurring. For example, the electrical energy use in the Northeast U.S. increased 4.9% in 1987, 3.1% above what was forecast. The signs are ominous: higher than predicted demand growth, inadequate new capacity additions, and dependency on high cost fossil fuels. This set of trends is the energy side of the situation; the environmental picture is less hopeful.

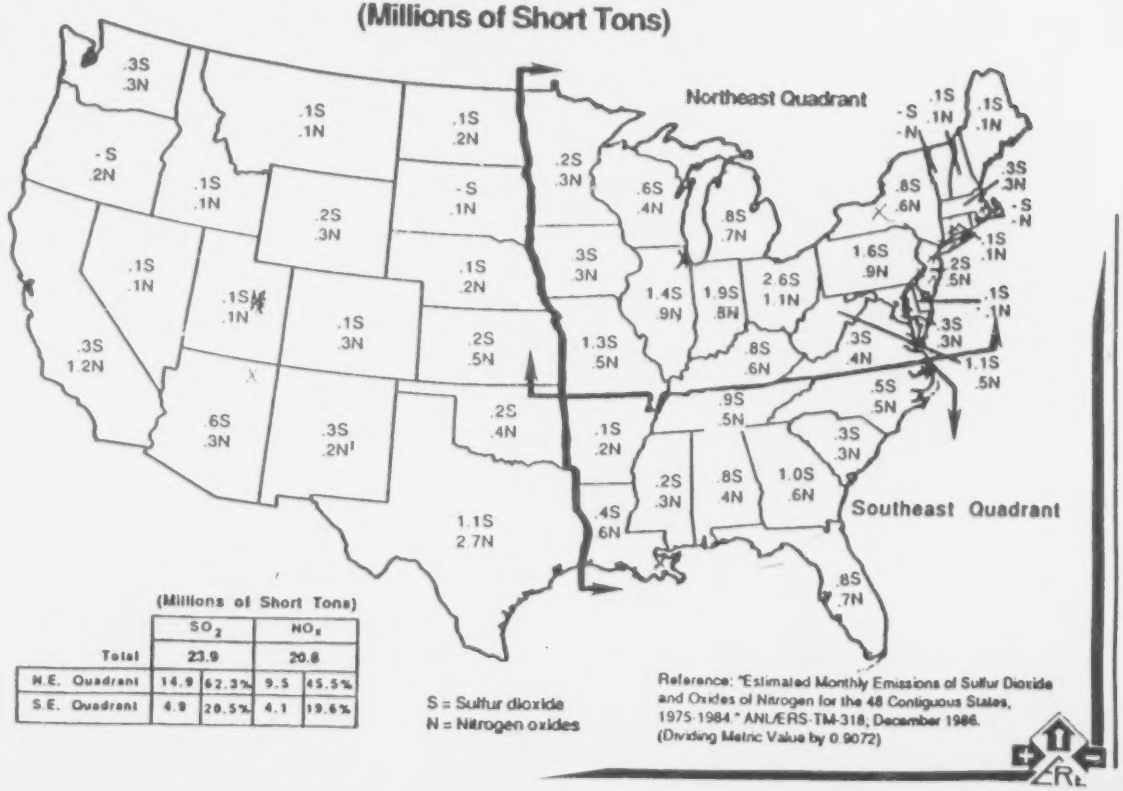
Connecticut, typical of the New England States, is a minor contributor to the nation's air pollution problems. That's the good news. The major U.S. air polluters are the states in the Northeast Quadrant. This area is bordered by Minnesota, Iowa, Missouri, Kentucky, and Virginia (Figure 1). This region accounts for over 62% of SO_2 and 45% of NO_X pollution generated in our country! Thus, what becomes clear is that Connecticut (and the other Northeast Coastal States) are victims of wind-carried and jet stream transported pollution from our Northeastern neighbors. In this situation, our only strategy is to encourage and, where possible, mandate air quality improvements that reduce transboundary pollution. The legislation before us can significantly assist in this area.

It is possible that an erosion of our area's economy could occur due to high cost energy, especially OPEC supplied oil. This coupled to a scarcity of electricity might lead to industry siting or relocating to other regions having a better energy outlook

FIGURE 1.

Emissions of SO_2 and NO_x in Continental U.S. (1984)

(Millions of Short Tons)



(Millions of Short Tons)

	SO_2		NO_x	
Total	23.9		20.8	
N.E. Quadrant	14.9	62.3%	9.5	45.5%
S.E. Quadrant	4.9	20.5%	4.1	19.6%

S = Sulfur dioxide
N = Nitrogen oxides

Reference: "Estimated Monthly Emissions of Sulfur Dioxide and Oxides of Nitrogen for the 48 Contiguous States, 1975-1984." ANL/ERS-TM-318, December 1986.
(Dividing Metric Value by 0.9072)

(and environmental quality). For example, while Texas is the leading oil-consuming state for power production, it uses domestically produced oil at pricing far below imported oil and enjoys relatively clean air as its southern location and flat terrain is regularly purged by air movements from the Pacific. Demographic trends already indicate increased migration of industry and population away from the Northeast and Mid-Atlantic areas. These New England energy and environmental scenarios can only be a further catalyst in the continuance of this trend. At the least, our region needs to develop strategies protecting our energy and environmental well-being and, in a very pragmatic sense, the socioeconomic "climate." The very low unemployment rates we enjoy at present may camouflage an impending series of adverse consequences at least partially impacted by the above-mentioned issues.

Where do fuel cells fit in? For sure, fuel cell provided power can go a long way to increasing electrical supplies and concurrently reducing air pollution while still using abundant domestic fossil energy resources. Because of the very high electric efficiencies possible (to 70%!) in the absence of primary combustion processes, CO_2 and acid rain producing NO_x and SO_2 exhausts are dramatically reduced or eliminated entirely. A comparison of current and advanced power generation options with respect to stack emissions is provided in Table 1. The closest alternative to fuel cell systems, the ISTIG option, still falls short in terms of efficiency, NO_x and CO_2 production. In fact, for a coal-based fuel cell power plant market penetration of only 10% annually from 1998-2010, a very significant emission reduction can be realized as indicated in Table 2. This is the promise of a successful introduction of fuel cell power to our nation.

A homebred Connecticut company, the Energy Research Corporation (ERC) celebrates its 20th Birthday next year. For the past 12 years, and with greater priority since 1982, we have perfected an "ultimate" fuel cell technology to where we are now committed to emplacing a pilot manufacturing facility by late 1991 with demonstration systems to be available starting in 1992. This equipment will be capable of using natural gas directly. That is, no external fuels processing other than sulfur cleanup will be needed before introducing the fuel into the fuel cell system, hence the name - Direct Fuel Cell (or DFC). Because of this feature, ERC has proven in tests at our Danbury plant, that a 60% electric efficiency is routinely obtained.

Complementing the technology development, ERC has also achieved a level of expertise in total systems design and analysis for both natural gas and coal-based fuel cell power plants in sizes from 2 - 200 MW, exemplified in Figure 2. These studies show a most impressive set of benefits. For the natural gas case an electric efficiency of 62% or a 5500 BTU/kWh heat rate, is attainable with a 30-year levelized Cost of Electricity (COE) of 37 mills/kWh (@ $4.00/mmBTU fuel cost) for a 200 MW power plant! With coal as the fuel source and utilization of current gasification technology, ERC has calculated a plant heat rate of 7300 BTU/kWh, equivalent to about 47% electric efficiency and a corresponding COE of 49 mills/kWh. Both systems would be more than competitive now, if they were available.

Very important to power plant owners are fuel flexibility and plant availability, a term representing the reliability of the supply at rated power. Also, a major consideration is the ability of the power provider (utilities by any other name) to meet a growing demand while controlling investment/revenue issues. ERC sees the concept of phased construction as the preferred modus operandi for utilities in the foreseeable future as contrasted to constructing large (∿ 1000 MW) central station power plants with their long lead time (∿ 10 years) and high early investment requirements (∿ $4000/kW). For the growth projection, natural gas fueled fuel cell modules (say in chunks of 10 MW) can be added as necessary to match the increasing demand until it becomes economically attractive to construct a coal gasification plant (say 200 MW). The fuel cell complement would switch to the coal-gas with natural gas as the backup fuel should the coal gasifier require maintenance. Further, because electrical supplies must be reliable (no outages), fuel cell modules can be replaced/serviced without degrading overall plant output.

TABLE 1

-Comparison of Stack Emissions-
Conventional and Advanced Systems
(lbs/MW hr Electric Output)

Fuel	System	Efficiency	SO_x	NO_x	SO_x+NO_x	CO_2
Natural Gas	Combined Cycle	43%	0	0.9	0.9	860-950
	ISTIG	50%	0	0.85	0.85	780
	Phos. Acid Fuel Cells	55%	0	0.2	0.2	1150
	MCFC/DFC	55%	0	0.08	0.08	640
Oil	Boiler	38%	8	3	11	1700
	Combined Cycle	42%	2.6	2	4.6	1350
Coal	Boiler - FB	38%	12	3	15	2150
	Boiler - PC	38%	12	6	18	2150
	Coal Gas/MCFC-DFC	45-47%	.05-0.5*	.01-.02*	.06-.07	<1600
	IGCC	40%	.2	1.0	1.2	1860
	AFBC	34%	8	0.8	8.8	2010

ABBREVIATIONS

AFBC - Atmos. Fluid Bed Combustion
FB - Fluidized Bed
DFC - Direct Fuel Cell
IGCC - Integrated Gasifier - Combined Cycle
MCFC - Molten Carbonate Fuel Cell
ISTIG - Intercooled Steam Injected Gas Turbine
PC - Pulverized Coal Combustion

* Coal Gasification Technology Dependent

TABLE 2

COMPARISON OF CGMCFC SYSTEMS WITH COMPETING COAL-BASED SYSTEMS:*

CGMCFC Systems Provide Superior Efficiency and Environmental Benefits at Competitive Cost-of-Electricity

	CGMCFC			COMPETING SYSTEMS		
Case Description:						
Gasifier/System	Entrained Bed (Texaco)	Moving Bed (BGL)	Fluidized Bed (KRW)	PC	AFBC	Fluidized Bed-IGCC
Oxidant	Cryo-O_2	Cryo-O_2	Cryo-O_2	Air	Air	Cryo-O_2
Gas Cleanup	Dow	Rectisol	Zinc Ferrite	FGD	In-Bed S	Zinc Ferrite
Efficiency (HHV%)	45.1	46.3	47.1	38.4	33.7	40.5
COE, mills/kWh	48.5	49.1	49.7	59.6	60.0	47.4
Environmental Emissions † (1998-2010):						
SO_x, 10^6 tons	0.3	1.8	0.02	30	30	0.6
NO_x, 10^6 tons	Trace	0.7	0.3	3.7	3.8	3.7
CO_2, 10^9 tons	5.8	5.7	5.9	7.7	7.8	6.9

* Values shown in this table are for a set of standard performance and economic parameters, according to EPRI TAG Guidelines for Illinois NO. 6 coal and a Chicago location.

† Assuming total 845 GW-yr power generated in the U.S. @ 10-GW/yr market penetration from 1998-2010.

Failures or periodic servicing of the fuel cell power plant are isolated to the fuel cell stack (or module level). When required to compensate for loss of the power output from a module, the remaining modules can operate in an overload condition until the maintenance action is completed (i.e. stack replacement). With no perceptible interruption in service almost 100% availability is contemplated.

These benefits are not pipe dreams. They are being proven now in development tests to the extent possible at this time. What remains ahead is to demonstrate megawatt-sized hardware to verify our projections and subscale tests. Over the next 2-4 years demonstrations will be underway. ERC is confident that the claims of high efficiency, quiet operation, low pollution power generation at very competitive capital and operating costs are in our grasp. A national policy that embraces these principles can significantly accelerate their realization on a large scale. The legislation being proposed in this Congress to improve our environment is a major step in this direction.

To be most effective, the proposed legislation needs to recognize several important actions:

- o Cite fuel cell derived power systems as a major contributor to the legislation's goals.
- o Specify an aggressive program with appropriate incentives to catalyze commercialization of the early, higher cost fuel cell systems.
- o Reward pollution reduction attainment by power producers without limitations to NSPS, i.e. establish a sliding scale of incentives vs. reductions.
- o Recognize the importance of a balanced energy policy for all domestically available energy sources (not only coal).
- o Place R&D funding priorities on high efficiency, low polluting power generation systems that show promise to meet our nation's thirst for electricity in mobility and stationary applications.

REFERENCES

1. 1988 Electricity Supply & Demand for 1988 - 1997, North American Electric Reliability Council.

2. America's Clean Coal Commitment, DOE Report by Office of Fossil Energy, February, 1987.

THE FUEL CELL

"A CLEAN POWER OPTION"

AUGUST 10, 1989

DR. WILLIAM J. LUECKEL, JR.

INTERNATIONAL FUEL CELLS CORPORATION

International Fuel Cells Corporation (IFC) is a subsidiary of United Technologies Corporation. It is located in South Windsor, Connecticut and has approximately 500 employees and annual sales of approximately $50 M.

Since 1967 IFC has worked closely with natural gas utilities in the United States to develop a family of phosphoric acid fuel cell power plants ranging from 10 kilowatts to about 1000 kilowatts output. These power plants would form the basis of the gas utilities offering an on-site energy service to their consumers.

In the on-site energy concept the gas utility would not only sell natural gas, as it does now, but would, with the use of fuel cells, convert the gas to heat and electricity for sale to the customer. The user would pay for the energy service provided rather than the gas used. Energy service is technically feasible in applications from multi-family residences to large industrial buildings, however, initially medium size commercial and multi-residential buildings are most economically attractive.

Although the on-site energy concept was created to aid gas utility business growth by expanding the scope of gas utility service, the inherent characteristics of fuel cell power plants result in the energy service also being essentially pollution free. There are virtually no SOx, NOx, or CO emissions, and there is less CO_2 output per unit of energy produced than from any other fossil power plant. Thus, on-site fuel cell energy

service could be a major contributor to the U.S. environmental goals of eliminating acid rain, bettering the quality of the air we breath, and minimizing global warming.

As a precursor to IFC and the natural gas utilities proceeding to commercialize a fuel cell power plant, a 40 kilowatt experimental natural gas/air power plant was field tested. The power plant was configured to provide all of the elements of natural gas on-site energy service. Between 1984 and 1986 approximately 50 units were manufactured, installed, and operated throughout the world in a comprehensive field test program. More than 350,000 hours of power plant operation were accumulated at more than 30 installations.

The assessment of the field test program was highly favorable. The Gas Research Institute, Department of Energy, and Utility participants judged the program to be a technical success. Site owners judged the fuel cell total energy service to be equal or superior to their existing service.

The success of the field test gave IFC the courage to proceed with the commercialization of an initial fuel cell power plant and to encourage gas utilities to initiate the sale of on-site energy service.

A self contained phosphoric fuel cell power plant of 200 kW rating was chosen for initial commercialization because it offers the best prospect

for early market acceptance. The power plant generates high quality alternating current electricity power more efficiently (40%) than conventional power generating equipment. It also provides another 40% of its input fuel energy in the form of useful thermal energy for heating hot water or producing steam. It operates quietly and unattended with basically no exhaust emissions. Therefore, it can be located near the building to be serviced. A picture of a preprototype 200 kW unit is shown in Figure 1. In addition, the measured NOx and SOx emissions from this unit are shown in Figure 2 in comparison to present EPA standards.

Our solicitation of U.S. utilities for power plant purchases has yielded only a limited amount of interest. We underestimated the negative impact the "least cost" philosophy of utility regulatory bodies has had upon willingness to initiate innovative concepts - regardless of the environmental benefits. Most U.S. utilities we have approached are unwilling to go forward with on-site energy service business development because they believe their utility regulators will not approve start-up costs associated with power plant installations in their rate structure. Interestingly, foreign governments have encouraged and subsidized their utilities to buy these initial units, largely because of their environmental benefits.

As an article in the July 26, 1989 issue of the New York Times (attached) pointed out, the future of the fuel cell in the United States will

largely be determined by the action, or inaction, of the public sector. For instance, if utilities generating electrical power are held to more stringent emissions standards in a revised Clean Air Act, the fuel cell will become an attractive element of new power generating scenarios.

Clean Air legislation is not the only way to encourage the commercialization of the 200 kW phosphoric acid fuel cell. Congress could take action to ensure the purchase of a number of units for use in government owned facilities such as V.A. hospitals, post office buildings, etc. Still another possibility would be to encourage utility purchase of initial units by eliminating the risk to their stockholders in the event commercialization is not successful. These are both low cost approaches to help a new "clean power" technology enter the marketplace. Without Congressional support the fuel cell will never become a reality in the U.S. We will eventually find ourselves working to solve our emissions problem by buying fuel cells manufactured abroad by foreign firms. The governments in Europe and Japan are aggressively subsidizing the development and commercialization of phosphoric acid fuel cell power plants, while our government is totally closing out federal participation.

200-kW PREPROTOTYPE FUEL CELL POWER PLANT

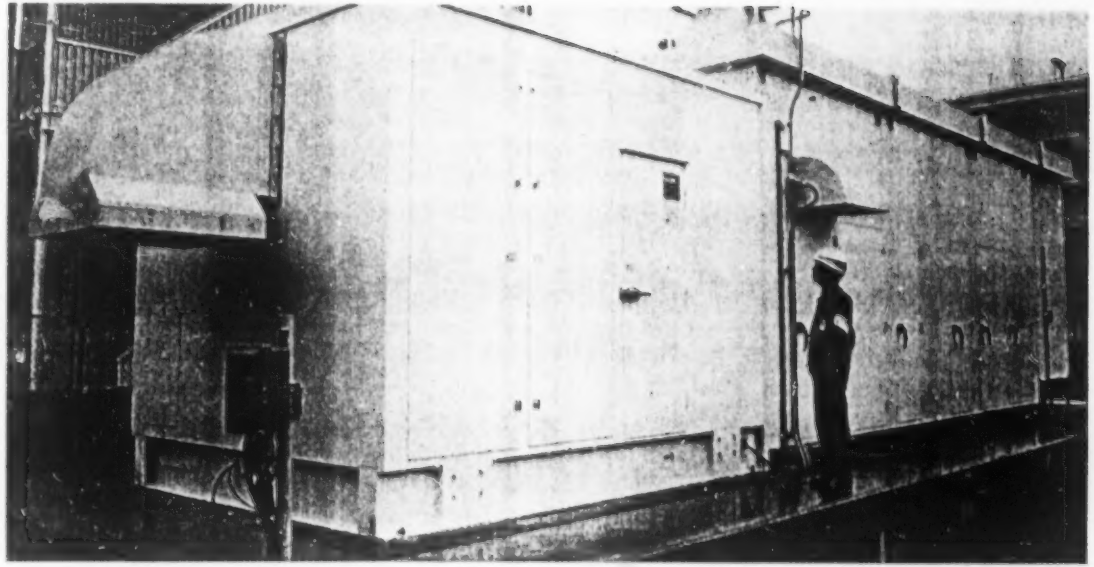
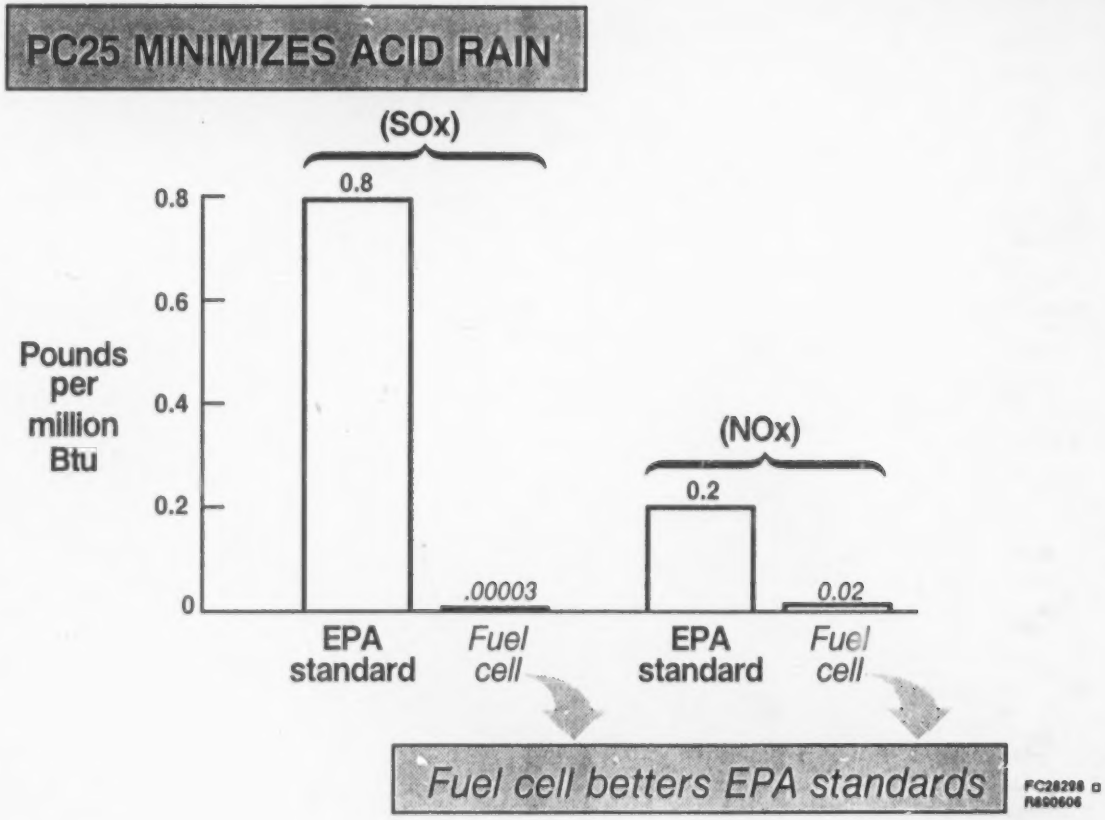


FIGURE 1

FC28379 ■
FU891004


PC25 MINIMIZES ACID RAIN
(SOx)
0.8
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0.6
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0
Pounds per million Btu
.00003
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Fuel cell
Fuel cell betters EPA standards
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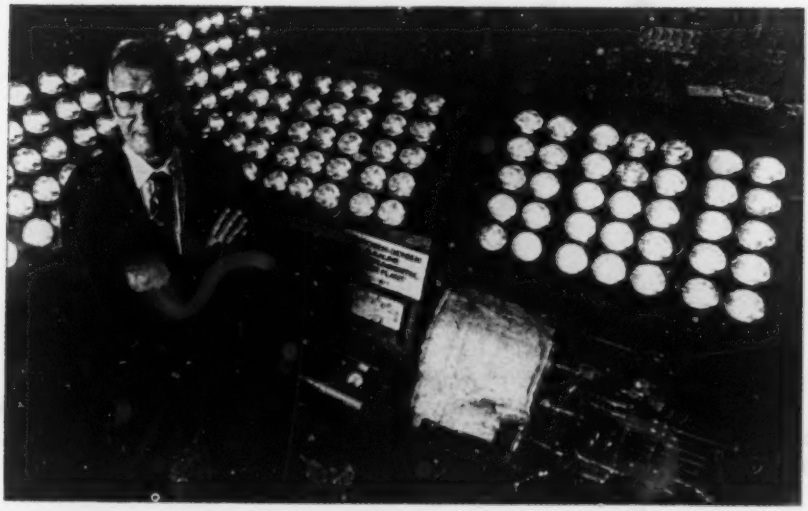
FIGURE 2

The New York Times

NEW YORK, WEDNESDAY, JULY 26, 1989

Interest in Fuel Cells Rises Again



The New York Times/Steve Miller

William Podolny, chairman of the International Fuel Cells Corporation, powering a bank of auto headlamps with an experimental 12-kilowatt hydrogen-oxygen alkaline power plant dating from 1973.

By JOHN HOLUSHA

Special to The New York Times

SOUTH WINDSOR, Conn. — Growing concerns about air pollution and the greenhouse effect have stirred new interest in fuel cells, devices that generate electricity through chemical reactions.

The appeal of fuel cells is clear. They are quiet, they produce little pollution, and they are more efficient than conventional power plants at converting the energy in coal, oil and natural gas into electricity.

But for nearly 30 years, high costs and the reluctance of both equipment manufacturers and electric utilities to plunge into new generating technologies — after disappointments with nuclear power — have kept the cells always on the horizon. Fuel-cell advocates say the time may now be right to overcome those obstacles.

The business spotlight is on the leader in the technology, the International Fuel Cells Corporation, a division of the United Technologies Corporation that is based here. I.F.C. has 53 orders for 200-kilowatt generating stations to be delivered in the early 1990's. But the company, which became involved with fuel cells through its work for the United States space program, has been reluctant to invest heavily in developing a business of supplying utilities.

Company executives say that before they start a production line they need about 100 orders, to bring average costs down, plus the financial and technical support of a partner familiar with the utility industry.

Other manufacturers in the United States, Europe and Japan are continuing to investigate fuel cell technology. I.F.C. says Japan's Fuji Electric Company has made the most progress toward developing competing models, spurred by five orders from Japan for I.F.C. fuel-cell plants of various sizes.

A 200-kilowatt generator could supply enough power to serve a 30-unit apartment building or a small factory. Initial commercial applications are expected in instances in which a natural gas utility, already supplying an industrial plant, offers electric power as part of a complete package.

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The concept of a fuel cell was described as far back as 1839, although the first practical applications came in the United States space program of the 1960's. Fuel cells provided power for the Gemini and Apollo missions and three fuel-cell units generate the on-board electricity for the space shuttles.

A fuel cell is a form of continuously operating battery. Inside the cell, a fuel, typically hydrogen, is passed over a negatively charged pole, or anode, where electrons are stripped off through catalytic action. The hydrogen ions that result then flow

through conducting substances known as electrolytes toward a positively charge pole, or cathode.

The electron flow produces an electric current. The hydrogen ions are left to combine at the cathode with oxygen, producing heat and water. The oxygen needed for the reaction can usually be taken directly from the air around the fuel cell.

Since the fuel is not burned in a conventional sense, there are no pollutants; in a cell with pure hydrogen and oxygen, water is the only byproduct. In others, depending on the fuel used, carbon dioxide is also produced, although in smaller quantities than from conventional processes.

"If you look at the proposed air-pollution regulations in Southern California, they are pretty draconian," said Edward Gillis, a project manager at the Electric Power Research Institute in Palo Alto, Calif. "Fuel cells may be the only game going there."

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Fuel cells are also more efficient than conventional power plants at converting hydrocarbons into electricity, because they do so through a direct chemical reaction. In a conventional plant, hydrocarbons are burned to boil water, creating steam that drives a turbine to generate electricity. Some energy is lost with each step.

"A conventional power plant is 34 or 35 percent efficient," said Manville Mayfield, a researcher at the Department of Energy's technical center in Morgantown, W.Va. "A fuel cell is as much as 45 percent efficient."

The fuel cell's advantage can be even greater if waste heat is captured in the form of steam and used to drive a conventional generator. Then the efficiency soars to between 70 and 80 percent, advocates say. Moreover, they say, the steam produced by a fuel cell is generally cleaner than that in a normal power plant, causing less corrosion.

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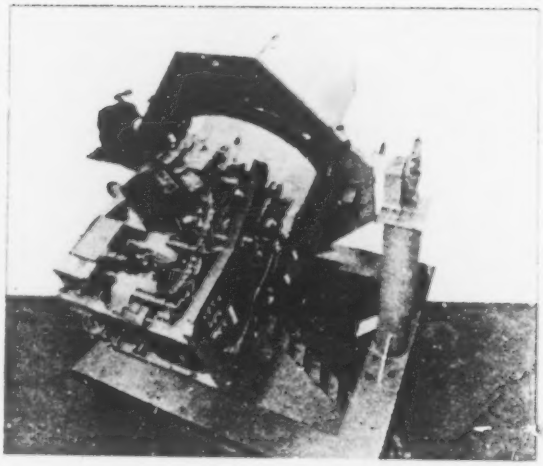
There are many kinds of fuel cells, each with attributes and drawbacks. The ones used in the space program have a solution of potassium hydroxide as the electrolyte and operate on pure hydrogen and oxygen.

Pure hydrogen and oxygen would be too expensive for ordinary power generation. Worse still, even the small amounts of carbon dioxide in the air will destroy the type of fuel cell used in space.



The New York Times/Steve Miller

A 16-kilowatt power plant on a space shuttle, one of three systems used.

Clean and quiet, the electricity-generating stations can be good neighbors.

I.F.C.'s most commercially advanced models use phosphoric acid as the electrolyte. They take oxygen from the air and use hydrocarbons drawn from oil or gas wells as fuel. The hydrocarbons are treated in a device called a reformer to create a supply of unattached hydrogen atoms. The 200-kilowatt generators that I.F.C. is preparing to build use phosphoric acid, as have the units, some of them larger, sold to Japan.

Using a petroleum-based fuel instead of pure hydrogen results in the emission of carbon dioxide, the gas believed responsible for much of the greenhouse effect. But because of the greater efficiency of fuel cells, less is emitted per unit of power than from conventional generators.

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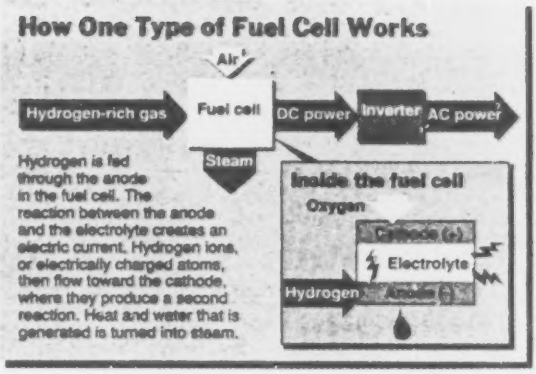
Two other types of fuel cells are under development. One uses molten lithium, potassium and sodium carbonates as the electrolyte and operates at a temperature of about 1,200 degrees Fahrenheit, compared with about 400 degrees for the phosphoric acid types. Molten carbonate cells could have electric conversion efficiencies as high as 57 percent and could free the hydrogen atoms from fuels without the need for a reformer.

Also emerging from the laboratory is a cell that does away with messy, corrosive liquids and uses solid zirconium oxide as the electrolyte. It operates even hotter — about 1,800 degrees — producing steam that can be used to run either heating or cooling equipment. But fabrication of the cells is difficult, and the technology is still being developed.

A typical commercial unit today consists of three main parts. At the front is the reformer, in which high-temperature steam is used to convert hydrocarbon fuel into relatively pure hydrogen and carbon dioxide. Then comes the cell itself, actually a stack of hundreds of small cells wired together to increase voltage.

The power that emerges is direct current, the kind that runs battery-powered devices. Since most electrical devices run on alternating current, the third main component is an inverter, which converts direct current into utility-quality alternating current.


How One Type of Fuel Cell Works
Air
Hydrogen-rich gas
Fuel cell
DC power
Inverter
AC power
Steam
Hydrogen is fed through the anode in the fuel cell. The reaction between the anode and the electrolyte creates an electric current. Hydrogen ions, or electrically charged atoms, then flow toward the cathode, where they produce a second reaction. Heat and water that is generated is turned into steam.
Inside the fuel cell
Oxygen
Cathode (+)
Electrolyte
Hydrogen
Anode (-)

Because they are made of many small cells rather than the boilers and turbines of conventional plants, fuel-cell systems can be built to fit an application. And since they are clean, quiet and need only a pipe to bring in fuel, they can be good neighbors.

"A fuel cell plant can be sited in a city next to an office building," said Daniel G. Lewis, director of technical services for the American Public Power Association, a trade group for local utilities.

The association and I.F.C. failed last year to agree on terms for developing 11-megawatt generators, which would have more than 50 times the capacity of I.F.C.'s 200-kilowatt units but about 1 percent of the capacity of a large nuclear power plant. The association then asked other manufacturers to submit propocals. Four were received and are being evaluated, association officials said.

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Those familiar with the situation say the chief barrier to more widespread use of fuel cells has long been economics rather than technology. Lower oil prices in the 1980's reduced the pressure on electric companies to seek new forms of generation, and problems with nuclear power threw all new technology into question.

In addition, the cost of being a pioneer is high. In its proposal, the public power group said early units might cost $1,500 to $2,000 per kilowatt of power, or $22 million for an 11-megawatt unit. The group believes the price has to be cut to $800 to $1,000 a kilowatt to be competitive with conventional generation.

William Podolny, chairman of I.F.C., agrees that it is a tough sell. "We are asking them to pay two and a half times what makes sense," he said. "That's a stretch for gas utilities that have to fight with regulatory commissions just to sell power."

Gas companies, seeing both an opportunity to broaden their market and a way to compete with electric utilities, are the main backers of I.F.C.'s 200-kilowatt project. All of the orders received so far have been from gas distributors in the United States, Europe and Japan.

A revised Clean Air Act, expected within a year, could force more utilities to consider fuel cells and other low-pollution methods of power generation. "It all depends on the criteria they set," Mr. Podolny said. "If they do it the way they did with automobiles — that utilities must be more efficient in generation and must get down to some level of emissions — then people will start spending money on new technology."